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ABSTRACT

This Energy Conservation Curriculum, developed for the Texas Education Agency, is designed to be used for teaching energy conservation in secondary, postsecondary, or adult/continuing education courses. It consists of 11 modules for use in practical, hands-on vocational programs that equip students with the ability to identify, monitor, manage, and curb energy usage in their daily lives and living habits. In addition, there is a comprehensive bibliography (included as module 12) of audiovisuals, books, games, government documents, journals and periodicals, and reports. A 20-minute, 3/4-inch video tape is available, wich explains both how the curriculum can be used and the concept of integrating the energy conservation modules into existing vocational programs. The modular arrangement of the curriculum facilitates learning by creating information packages that can stand alone or be used with other modules or resources. To aid in the implementation of the curriculum, pretests and posttests have been developed for each module; separate bibliographies and lists of terms have also been included. Reproducible charts and graphs are supplied to serve as the basis for handouts and transparencies. Material covered in the modules includes the following: awareness of the energy dilemma; energy usage; understanding utility bills; energy conservation opportunities--water, lighting, appliances; energy consumption as related to building construction; human comfort and energy; heating, ventilating, and air conditioning conservation opportunities; and the economics of energy conservation. (KC)

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ENERGY CONSERVATION

FOR VOCATIONAL STUDENTS:

Secondary
Postsecondary
Adult/Continuing Education

By

C. Paul Green--Project Director

Charles Orsak--Curriculum Development Specialist

CE 029 131

materials developed by
Navarro College

in cooperation with
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U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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PREFACE

Energy...everbody needs it...everybody uses it. But, how much we really need, and just how wisely we are using it, is the subject of many conversations...among those who have to endure the energy crisis ...to those in government who must plan for it.

The increasing shortage of oil and natural gas, coupled with the rapidly escalating price of fuel in the United States has placed us in a new era, where the lack of cheap fuel for industry and services threatens our present standard of living and our national defense.

One area which must play an important role in correcting this situation is the American educational system. Students must be taught to understand the global energy crisis...and must be trained in the vocational and technical skills needed to recognize the essential and wasteful uses of energy.

Until now, their education in the energy crisis has come from a variety of unpleasant personal experiences that center around rising gasoline costs...higher utility bills...and reduced availability of the energy they need.

Students were not being taught the skills necessary to cope with this problem.

But, through an Energy Conservation Curriculum developed by Navarro College, an immediate contribution can be made to our society, by developing a labor force who will know how to implement energy conservation measures.

This Energy Conservation Curriculum, just completed for the Texas Education Agency, is designed to help correct this lack of instruction concerning energy conservation.

We have developed an eleven module curriculum for use in practical, hands-on secondary and postsecondary vocational programs. This curriculum equips students with the ability to identify, monitor, manage, and curb energy usage in their daily lives and living habits.

In addition, there is a comprehensive bibliography of audiovisuals, books, games, government documents, journals and periodicals, and reports included as Module XII. A twenty-minute, 3/4 inch video tape is available which explains how the curriculum can be used and the concept of integrating the energy conservation modules into existing vocational programs.

Charles G. Orsak, Jr.

Curriculum Development Specialist

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USE OF THE INSTRUCTIONAL MODULES

The proposed utilization of these modules is to support existing related curricula in such areas as home economics, agriculture, air conditioning and refrigeration, the building trades and electronics. But, it can be used in many other fields.

The key to this special curriculum is its flexibility. It has been produced so that it can be used in high school and college-level programs, vocational training, and adult education.

Its flexibility extends to its implementation. If desired, the curriculum can be used as an entire course, in itself. But, its true strength lies in the ability to insert separate modules into already-existing curricula, and its usefulness as a resource tool.

The modular arrangement of this curriculum facilitates learning, by creating information packages that can stand alone, or be used with other modules or resources.

To aid in the implementation of the curriculum, pre-tests and post-tests have been developed for each module; separate bibliographies and lists of terms have also been included. And, reproducable charts and graphs are supplied, to serve as the basis for handouts and transparencies. Information on the charts is reinforced by its inclusion in the body of the text.

The modules are produced so that text materials appear on the left half of the page, while instructions or lab presentations are given on the right.

In developing this curriculum, every effort has been made to provide a clear, concise presentation that can be used in a variety of settings.

To get a better idea of what the curriculum includes, and how it can be used in your programs, let's take a brief look at the individual modules.

Module I, Awareness of the Energy Dilemma, enlightens students as to the critical factors involved in our growing energy crisis. It includes a review of our current energy sources, including gas... oil...coal...nuclear...and hydro-electric power. Also included is a survey of the potential energy alternatives--solar power...wind power...geothermal wells...tidal power and ocean thermal energy conversion.

Used to introduce participants to the many aspects of the energy crisis, this module explains the use, and misuse of our energy resources. It also points out future energy problems.

This module was designed for use in general instructional situations. It can also be used in history and science courses, economics, electronics, home economics, as well as for vocational courses in heating and air conditioning.

Module II, called Surveying Energy Usage, examines America's use of energy resources. While this module is of great interest to home economists, it can also be used in such fields as industrial arts, agriculture, heating and air conditioning, history, business and science.

This module presents an overview of our use of energy by concentrating on four main usage categories--commercial...industrial... agricultural...and transportation. The importance of energy to each of these areas is discussed. By understanding our society's reliance on energy, students become aware of the need for conservation. This module also proposes solutions, and examines them for their practicality and adaptability.

Module II will train students to recognize energy needs and consumption patterns. Furthermore, it will prompt students to search for, and implement, ways to conserve energy in residential, commercial, industrial, agricultural and transportation situations.

The contents of Module III are of interest to everyone. Entitled Understanding Utility Bills, this module examines utility bills used for commercial and residential customers. The electric bill is discussed in terms of terminology and definition, cost breakdown, meter readings and rate schedules.

Natural gas utility bills are discussed in terms of terminology and definitions, heat content, cost per unit, meter reading and rate schedules.

The best way to lower personal utility bills is to monitor one's energy consumption. By identifying and understanding the different types of meters used, and by becoming familiar with how energy usage and meter rates combine to make a utility bill, the student will be able to evaluate his or her own energy usage, and will be able to determine the effectiveness of their energy conservation.

While the information in this module is valuable to everyone, it is extremely useful in the study of business management, science, home economics, math, public administration, agriculture, and the vocational fields.

Module IV, How to Search for Energy Conservation Opportunities, offers energy-saving ideas that are of help to everyone. Not only does this module emphasize the importance of recognizing the ways in which energy is consumed in the home, it also develops a consumer awareness of energy efficiency and management. Energy conservation techniques for the home are discussed, as are ways to monitor energy use and conservation.

This module helps homeowners, contractors, and others in the building trades, heating and air conditioning specialists, home economists, and anyone living in a residential dwelling, by training them to recognize energy users in the home, and by showing how energy conservation and management plans can be implemented.

Module V touches on one use of electricity that affects us all. The use of electric lighting is universal and this module, entitled Lighting Conservation Opportunities, shows how students can save energy (and money) and still get the light they need.

This module reviews the different types of lighting fixtures used in residences and commercial buildings, and compares them in terms of energy usage, and light and heat output. It discusses the proper light level needed for different activities, color definitions and time elements for usage. The module concludes with helpful suggestions that will enable people to implement their own lighting conservation programs.

Module VI, Water Heating Conservation Opportunities, also addresses one specific area of conservation. As with lighting, water heating is used throughout our nation. Thus, this module is of great value to home economists, building superintendents, apartment and commercial property owners, heating and air conditioning workers, utility workers, scientists--anyone who uses hot water at home or at work.

This module discusses the different types of water heaters in use. Their operating characteristics and efficiency are compared from the standpoint of input energy, heat loss, and recovery capacity. Also discussed are the temperature variances for different water heating appliances. Thirdly, family habits are examined in order to ascertain how families of different sizes can use heated water more efficiently.

Module VII, Appliance Energy Conservation Opportunities, introduces the student to various household and small commercial appliances. This module discusses these appliances in terms of their operations, energy usage, efficiency and cost of operation. Ways to make these appliances more efficient, as well as alternatives to their use, are also presented.

The student will learn to determine the energy efficiency ratings of various appliances. In addition, ways of relating the ratings to energy conservation opportunities, and the benefits of taking advantage of these opportunities, are also discussed.

While Module VII is of obvious value to appliance users, electricians, appliance dealers and repair people, business people and office workers can also make use of the valuable information contained in this chapter.

Module VIII is entitled Building Construction Versus Energy Consumption. It discusses heat transfer in buildings as well as specific characteristics that affect heat loss and heat gain.

While reviewing factors such as heat conduction...convection... radiation...evaporation...and others, this module also discusses the basics of building codes and regulations. By doing so, the student becomes familiar with the ways in which a building's physical properties affect energy consumption.

The student also learns how to calculate heat loss and gain in relation to weather factors, and how to analyze the costs and benefits of energy conservation opportunities.

To help the student, a workbook for surveying heat loss and gain is provided. Included in this workbook are the formulas necessary for determining the costs and savings of different energy conservation measures.

Homeowners, those in the construction trades, as well as owners and users of commercial buildings are sure to find this module to be a helpful tool in their energy conservation campaigns.

Whenever we think of energy conservation, we automatically think of sacrifices and inconveniences--fewer weekend outings, cancelling long trips and the like. But, the most troublesome sacrifices are those that affect our physical comfort.

Human Comfort and Energy Conservation is the topic discussed in Module IX. This module serves as an introductory study of the integration of energy consumption and maintenance of human comfort. The different variables affecting the relationship between human comfort and energy are examined in this module.

It also defines how the factors of both natural and artificial environments affect human comfort. It shows how human factors, such as the number of people in a room, the duration of their stay, their activity and the clothing they wear, will affect thermal controls in homes and places of work.

Finally, the module discusses both active and passive control measures for achieving energy conservation without causing human discomfort.

This module is geared to help students of home economics, the construction trades, biology, psychology, physics, electrical engineering and heating and air conditioning in their understanding of energy use in regards to human comfort.

While of obvious interest to students and technicians in the heating, ventilating and air conditioning fields, Module X, Heating, Ventilating and Air Conditioning Conservation Opportunities provides ways for all homeowners, residents and commercial building occupants to conserve energy in the use of climate control systems.

By examining the basic factors involved in heating and cooling through discussion of the different elements of efficiency, operation and maintenance of heating and cooling systems, and by becoming familiar with the various arrangements and operating specifications of ductwork and duct insulation, this module shows students how energy is used and can be saved in heating and cooling.

The final presentation in this curriculum is Module XI, Economics of Energy Conservation. This module is a practical discussion of the costs of energy conservation measures, and the savings and benefits, in energy and dollars, that these measures can bring.

By prioritizing energy conservation measures, analyzing implementation costs, and by identifying potential energy use trade-offs, the student will learn to develop a comprehensive conservation plan to fit his or her situation and needs.

To help students in developing a workable plan, this module discusses the traditional American philosophy towards energy use, it examines the various ways of generating electricity, and identifies the cost, operation, and the efficiency, of lighting systems, appliances, and automobiles.

This module also helps students determine investment costs and savings for insulation materials, payback periods for conservation measures, and the usefulness of retro-fit measures for conservation in existing buildings.

Used by itself, Module XI gives a concise explanation of how energy conservation techniques will help the individual in the long run. Used in conjunction with other elements of this curriculum, this module wraps up the curriculum by condensing and reviewingkey concepts and practices in energy conservation.

The 11-module curriculum is supplemented with a twelfth module as a comprehensive bibliography of books, journals, government documents, audiovisuals, films, filmstrips, records, transparencies, and games available to support the various modules. Instructors will find this information helpful in preparing their lessons and reinforcing energy conservation concepts within the curriculum.

The different components are color-coded for quick recognition:

white--objectives, bibliography, terminology, transparency masters, text and activities

green--information sheets

brown--all student material

yellow--tests

pink--answers

As you can see, Navarro College's Energy Conservation Curriculum serves as a great aid to those wishing to learn more about this subject that is of increasing importance.

Its modular flexibility allows it to be used in a variety of ways. The breakdown of the individual modules into separate units is designed to facilitate the use of this resource.

Instructors can make use of this information as a total package, or can pinpoint specific information for inclusion in their own presentations.

By educating Americans in the practices of energy conservation, we take a great step forward in securing our future as an energy-consuming nation.

MODULE I

AWARENESS OF THE ENERGY DILEMMA

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. It is intended for use independently, integrated with the other 10 modules into a program on energy conservation, or integrated into conventional vocational courses as a unit of instruction on the "Awareness of the Energy Dilemma."

MODULE I

AWARENESS OF THE ENERGY DILEMMA

The objective of this module is to instill awareness that there is a growing crisis in energy supply. Therefore, attention and concern must be evidenced by all citizens in order for conservation to take place and energy to be available for future use.

MODULE DESCRIPTION:

An overview is made of energy supply sources including oil, gas, coal, nuclear, and hydro-electric power. A survey is made of potential or alternate energy sources which now are getting much attention. These include solar, wind, geothermal, tidal, ocean thermal, biomass, and other types of power. Types and amounts of energy used are discussed, and uses of energy are outlined. Finally, an overview of energy opportunities and their problems are listed.

INTRODUCTION:

Oil production by the United States has been declining since 1970, while usage continues to increase. Importing foreign oil means exporting dollars: in 1970, the U.S. spent $3 billion for foreign oil...$15 for every American. In 1977, the U.S. spent $34 billion for oil, or $160 for every man, woman, and child in the U.S." The U.S., which represents 6% of the world population, uses 1/3 of the world's production of energy. This inbalance presents serious problems in terms of the challenge to America's lifestyles prompted by declining sources of inexpensive fuels.

This block of instruction is an introductory overview of the energy problems facing the nation. The module presents a survey of energy resources, an examination of energy uses, and a discussion of the potential for alternate energy sources which are receiving considerable attention at present.

GOAL STATEMENT:

Upon completion of this module, the student will be able to:

a. Exhibit an understanding of energy sources and alternate sources now available to society;

b. Demonstate an understanding of energy uses in U.S. society;

c. Indicate a better understanding of the disproportionate use of energy today in contrast to cultures and societies of the past and present which were less energy-oriented.

READING GRADE LEVELS:

Lecture : 17
Lab : 8
Hand-Out: 15

SUGGESTED TEACHING TIMES:

Secondary : 2 hours
Postsecondary: 1 hour

MODULE I

AWARENESS OF THE ENERGY DILEMMA

UNITS:

- I. Energy Sources
    - A. Changing Energy Sources/Uses
    - B. Fossil Fuels
    - C. Fossil Fuels in Texas
        - (1) Oil and Gas in Texas
        - (2) Coal in Texas
    - D. Energy Depletion Rates
    - E. The Energy Crisis
- II. Renewable/Alternate Energy Sources
    - A. Biomass Conversion
    - B. Solar Energy
    - C. Wind Energy
    - D. Ocean Sources
        - (1) Ocean Thermal Energy Conversion
        - (2) Tidal Generators
    - E. Geothermal
    - F. Nuclear
        - (1) Conventional Reactors
        - (2) Breeder Reactors
        - (3) Nuclear Fusion
    - G. Oil Shale
    - H. Tar Sands
    - I. Problems

    SUMMARY

MODULE I

AWARENESS OF THE ENERGY DILEMMA

TERMINOLOGY

Bitumen--any of various mixtures of hydrocarbons (as tar) often together with their non-metabolic derivatives that occur naturally or are obtained as residues after heat-refining naturally occurring substances (as petroleum).

Breeder reactor--a nuclear device that produces more fissionable material than it consumes.

British thermal unit (Btu)--a unit of heat energy equal to the heat needed to raise the temperature of one pound of air-free water from 60° to 61° F, at a constant pressure of one standard atmosphere.

Calorie--a unit of heat energy equal to the heat required to raise the temperature of one gram of water from 14.5° to 15.5° C, at a constant pressure of one standard atmosphere.

Coal gas--a gaseous mixture produced by the destructive distillation of bituminous coal and used as a commercial fuel.

Cubic foot of gas--a unit of measurement for volume of gas. It is equivalent to one foot cubed of volume.

Deuteruim--the isotope of the element hydrogen, with one neutron and one proton in the nucleus.

Energy--the capacity for doing work.

Fossil fuels--energy sources ultimately derived from living things (coal, oil, natural gas)

Geothermal energy--pertaining to heat energy within the earth.

Kilocalorie--a unit of heat energy equal to 1,000 calories.

Nuclear fission--the division of an atomic nucleus into parts of comparable mass; usually restricted to heavier nuclei such as isotopes of uranium, plutonuim, and thorium.

Nuclear fusion--combination of two light nuclei to form a heavier nucleus (and perhaps other reaction products) with release of some binding energy.

Nuclear power--energy derived from power whose source is nuclear fission or fusion.

Oil shale--oil produced or captured from a fossil rock that is formed by the consolidation of clay, mud, or silt; has a finely stratified or laminated structure; and is composed of minerals essentially unaltered since deposition.

Solar energy--pertaining to the heating property of the sun.

Strip mine--a mine that is worked from the earth's surface by the stripping of overburden.

Water power--pertaining to the energy capability of water and its volume, weight, or temperature stratification.

Wind power--pertaining to the energy capability of wind with its movement.

MODULE I

AWARENESS OF THE ENERGY DILEMMA

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MODULE I

AWARENESS OF THE ENERGY DILEMMA

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. Oil production in the United States has been declining since:
   - a. 1940
   - b. 1950
   - c. 1960
   - d. 1970

2. In 1977, the United States imported about _______ percent of the total oil consumed.
   - a. 10
   - b. 15
   - c. 25
   - d. 50

3. The first external source of energy that people used to aid them in their labors was:
   - a. wind
   - b. geothermal
   - c. fire
   - d. solar

4. Today, about _______ percent of the energy supplied for our use comes from fossil fuels.
   - a. 10
   - b. 25
   - c. 55
   - d. 95

5. In 1850, the major fuel source available was:
   - a. coal
   - b. natural gas
   - c. petroleum
   - d. wood

6. Since 1950, energy consumption has increased by nearly _______ percent over the 1950 level.
   - a. 50
   - b. 100
   - c. 300
   - d. 400

7. More than 60% of the world's oil reserves lie in:

   a. the United States
   b. Canada
   c. the Middle East and North Africa
   d. Australia

8. _______ provides 1/3 of our nation's energy needs:

   a. natural gas
   b. coal
   c. petroleum

9. _______ County was the site of the first commercial oil field in Texas:

   a. Navarro
   b. Kilgore
   c. Nacogdoches
   d. Hill

10. _______ is the most abundant of fossil fuels:

    a. petroleum
    b. coal
    c. natural gas

11. _______ is a renewable energy source:

    a. natural gas
    b. petroleum
    c. coal
    d. wood

12. _______ to _______ acres could produce enough wood to heat one home indefinitely:

    a. 1 - 2
    b. 3 - 6
    c. 6 - 12
    d. 20 - 30

13. Solar can be used to produce electricity inexpensively.

    a. true   b. false

14. The technology necessary to build nuclear plants is well established.

    a. true   b. false

15. Nuclear fusion technology is now developed to the point that it may be used commercially to produce electricity.

    a. true   b. false

16. In 1900, the major energy source in the United States was:

    a. wood
    b. coal
    c. petroleum
    d. natural gas

17. There are really no technical problems associated with the use of wind power to generate electricity for our homes.

    a. true b. false

18. The use of solar energy as a prime source of energy could cause serious pollution in our nation.

    a. true b. false

19. The use of solar to heat water dates back to the 1920s.

    a. true b. false

20. Which individual uses the most energy each year?

    a. a German
    b. a Russian
    c. an American
    d. a Puerto Rican

MODULE I

AWARENESS OF THE ENERGY DILEMMA

ANSWERS TO PRETEST

1. d. 1970
2. d. 50
3. c. fire
4. d. 95
5. d. wood
6. d. 400
7. c. Middle East and North Africa
8. a. natural gas
9. c. Nacogdoches
10. b. coal
11. d. wood
12. c. 6-12
13. b. false
14. a. true
15. b. false
16. b. coal
17. b. false
18. b. false
19. a. true
20. c. an American

MODULE I

AWARENESS OF THE ENERGY DILEMMA

UNIT 1

ENERGY SOURCES

UNIT OBJECTIVES

1. Recognize the conventional sources of energy in the U.S.
2. Discuss the historical change in dependency on these fuels.
3. Relate the role of Texas in the U.S. production of energy.
4. Appreciate the rate of fossil fuel depletion.
5. Discuss the three types of energy crises existing today in the world.

MODULE I

AWARENESS OF THE ENERGY DILEMMA

UNIT I

ENERGY SOURCES

LECTURE	ACTIVITIES
INTRODUCTION:	
The United States' oil production has been declining since 1970, while usage continues to increase. In 1977, the United States imported about fifty percent of total oil consumed. This dependency on imports has a serious disadvantage. The tremendous trade deficit produced makes it impossible to achieve a balance of trade under these conditions. The result is a serious blow to the stability of the United States' currency in the international market, is a threat to our defense posture, and makes energy conservation extremely important.	A student handout of textual material is available at the end of this module.
Is there really an energy shortage? In reality, there are worldwide shortages. The problem is not only a shortage of oil and natural gas, but other important energy sources are also declining. Conservation cannot solve all of our energy problems, but it can help. Conservation does not mean doing without things, but using what we have more efficiently.	
Voluntary reduction of energy consumption, however, is only one approach to coping with the energy crisis. Research is being conducted on future possibilities for electricity supplied through solar and geothermal energy, wind power, breeder reactors, oil shale, coal liquification, and nuclear fusion by	

using the unlimited deuterium hydrogen resources in the sea.

It is impossible to be unaware of energy. Newspaper and magazines print articles about the energy crisis and the methods by which we hope to solve the problem. Meanwhile, utility bills rise rapidly, goods and services cost more, and personal paychecks lose buying power.

Many people think of energy simply as a power plant or a steel mill, an electrical generator, or a tank truck on the road. Actually, wherever we have heat, light, or motion, we have energy in action. We need to recognize that energy is present in a lump of coal, a battery, or a piece of uranium. This energy can provide us with heat, light, or motion and must be used conservatively to be most efficient.

The chief worldwide sources of energy in order of importance are: fossil fuels, water power, and nuclear energy. In addition, solar energy, wind power, tidal energy, and geothermal power provide small amounts of energy. (Figure 1.1) Historical perspective indicates that emphasis on fossil fuels, water power, and nuclear energy is strictly a contemporary focus.

A. CHANGING ENERGY SOURCES/USES

In the most primitive society, life for people was very much like that of the animals in the same area. People consumed about 2,000 kilocalories of energy per day in food through life processes and hunting for survival. With the use of simple stone tools, social organization progressed with some division of labor: hunters, gatherers, preparers.

A calorie is:

1(a) The amount of heat required at a pressure of one atmosphere to raise the temperature of one gram of water one degree centigrade--called also "gram calorie" or "small calorie".

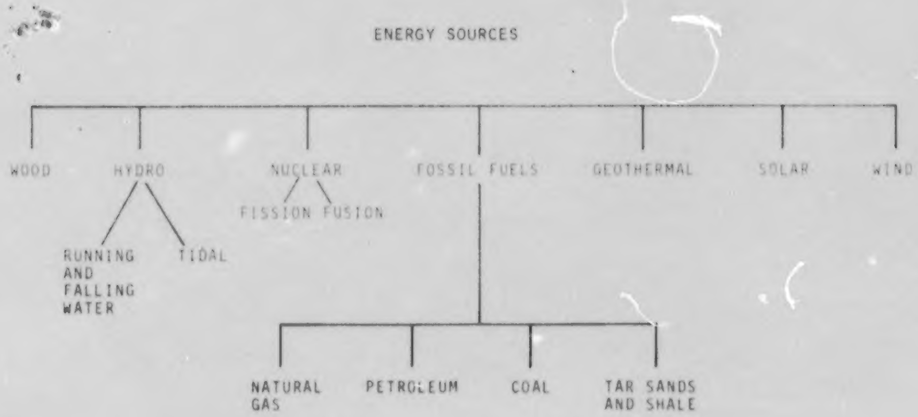


FIGURE 1.1

The event of fire was the first external source of energy which people used to aid them in their labors. This one item accounts for the additional 3,000 kilocalories of energy of the 5,000 kilocalories which each primitive person spent per day.

Each advancement in social organization brought with it an increase in energy input. A simple plow drawn by an ox enabled one person to provide food for several, but oxen used energy while providing power which is compared to energy input. With each additional input of energy, fewer people were able to produce and provide more items and services for more people, thus freeing some for other pursuits. This process has increased through industrialization and technology until the average American today consumes some 220,000 plus kilocalories of energy per day.

Today, about 95% of the energy supplied for our use comes from the fossil fuels--oil, natural gas, and coal. (Figure 1.2) This is a dramatic change in energy sources in the United States over the past

1(b) The amount of heat required at a pressure of one atmosphere to raise the temperature of one kilogram of water one degree centigrade--1,000 gram calories or 3.968 Btu--also called "kilogram calories" or "large calorie".

A kilocalorie is:

2(a) A unit equivalent to the large calorie expressing heat-producing or energy-producing value in food when oxidized in the body.

2(b) An amount of food having an energy-producing value of one large calorie.

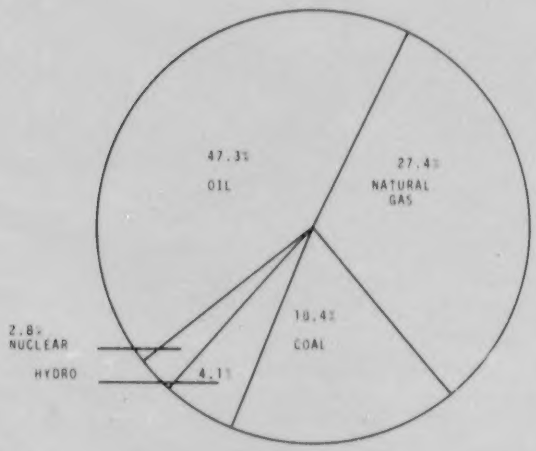
Hence, when we speak of "kilocalorie", we are speaking of the large calorie. The early person found the 2,000 kilocalories for survival when and where possible. Today, because of all of our demands to "live the good life," the average citizen of the United States consumes between 220,000 and 240,000 kilocalories of energy each day. By "consume" we mean that one person uses this much energy, or requires the use of this much energy, in

125-150 years, and the implications of these changes have been the basis of our present energy dilemma.

order to follow a daily routine (cooking food, running appliances, transportation, performing work, etc.).

HOW U.S. ENERGY NEEDS ARE SUPPLIED

HOW MUCH OF OUR ENERGY COMES FROM EACH SOURCE?



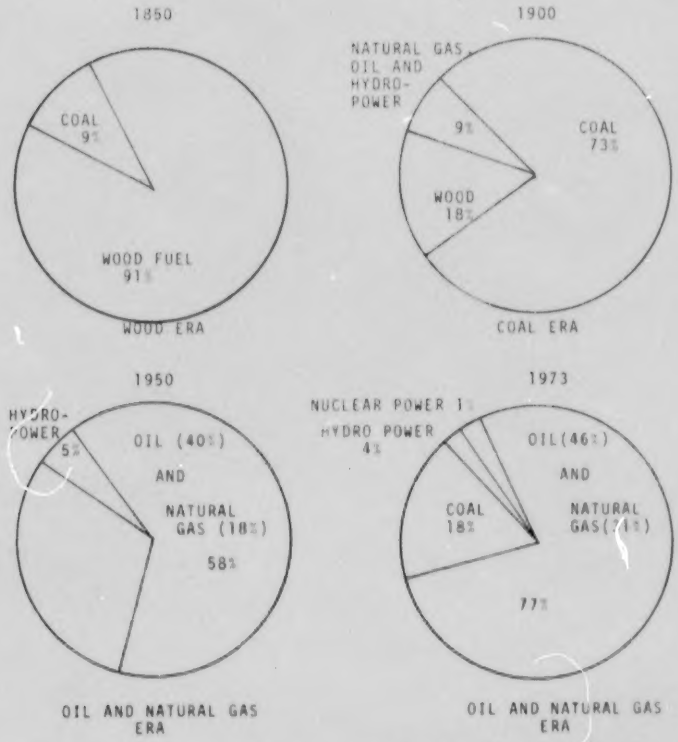
U.S. TOTAL ENERGY SUPPLY

SOURCE: CREATING ENERGY CHOICES FOR THE FUTURE.

FIGURE 1.2

In 1850, the major fuel source available was wood, even though some hydropower was used to turn wheels for mills, and the use of steam engines. Wood was inexpensive and widely available, though some shortages developed periodically near growing cities. As long as wood was the major fuel, the ratio of humanpower expended to energy produced remained low. Coal was required in some instances, and required a large input of humanpower to produce. Coal, however, was less bulky than wood for a given energy content, and was easily transported and stored. The increase in manufacturing and industry from 1850-1900 was as much due to better and large energy supply in the form of coal as it was to the inventiveness that provided the machinery. (Figure 1.3)

CHANGING PATTERNS IN THE USE OF ENERGY RESOURCES
IN THE UNITED STATES



What will the year 2000 bring? NUCLEAR FISSION ERA? NEW COAL ERA? NUCLEAR FUSION, GEOTHERMAL, SOLAR, WIND ERA? ENERGY CONSERVATION ERA? LOWER PER CAPITA ENERGY USE?

SOURCE: U.S. BUREAU OF CENSUS AND RESOURCES FOR THE FUTURE

FIGURE 1.3

From 1900-1950, the shift was made fom coal to oil and natural gas as the major energy sources and the total energy consumed in the United States increased about 300 percent. The major reason for this change from coal to oil and gas was still the humanpower--energy-produced ratio and ease of transportion and storage. Since 1950, energy consumption has increased by nearly 400 percent over the 1950 level, and an even greater share of energy has been produced from oil and natural gas. (Refer to Figure 1.3)

In 1973, the U.S. experienced an oil embargo by the oil producing countries of the world. Discuss the inconveniences and frustrations you experienced by this action.

The political situation in Iran promises to have the same type of effect on the U.S. in 1980. Is the U.S. better prepared in the 1980s to face the situation than in 1973? Explain.

B. FOSSIL FUELS

More than 60 percent of the world's oil reserves lie in the Middle East and North Africa. The reliance by industrialized nations on Arab oil gives the Middle Eastern nations considerable power. As fuels become scarce, prices go up.

In 1974, Arab oil accounted for 14 percent of all U.S. imports. Currently, it is over 40 percent and growing rapidly. Altogether, the U.S. imports over half the oil it consumes and is currently paying over $40 billion a year for it. At the current rate of increase in consumption and oil prices, we can expect to be paying about $120 billion for imported oil by the year 2000, compared to spending $25 billion in 1974.

Natural gas provides one-third of our nation's energy needs. If gas energy is to continue serving essential needs plus new uses being developed for the future, where will supplies come from? Obviously, the most desirable source would be from new fields or more deeply developed reserves. The most promising potential sources of gas in this area are three basins on the outer continental shelf--Georges Bank, east of New England and New York; Baltimore Canyon, east of Maryland, Delaware, and New Jersey; and Blake Plateau, east of Georgia and Florida. Experts estimate that exploration and development of the Atlantic offshore basins might produce up to 200 trillion cubic feet of gas and 50 billion barrels of oil. Gasification of coal is another means of gas production, but it is a long-term goal.

Locate these natural gas reserves on a United States map. What problems in transporting the gas to the customers do you see?

Coal has been in use at various places on earth for over 800 years, but over one-half of the coal has been mined in the past 40 years. Even though coal has been providing less and less of our total energy supply, the amount of coal mined each year has been increasing. Much of it comes from the southern region of the United States, and Texas has figured prominently in the U.S. production of fossil fuels.

C. FOSSIL FUELS IN TEXAS

Although energy in Texas is abundant, it is not unlimited. Texans should be aware of the energy sources in the state and have a concern about energy use and conservation so that the years ahead will be pleasant and profitable. Texas has an energy problem to solve because the state plays a large role in the energy picture in the United States, both as producer and consumer. With conservation and efficiency in the use of its energy sources, Texas can maintain its position as a major supplier of energy to the nation. With improved technology to create new sources of energy, coupled with the wise use of the energy Texas now has, the future should be bright not only for Texas but for the nation.

(1) Oil and Gas in Texas

The Indians were the first to find oil in Texas. When the explorers arrived, the Indians told them the oil had medicinal values. History records that Europeans exploring Texas used crude oil for caulking boats, such as in 1543 in the De Soto expedition near Sabine Pass.

The first drilled well to produce oil in Texas was at Melrose, in Nacogdoches County. To reach the oil, the driller,

Ask the class if anyone has ever seen a piece of coal, or smelled it burning. "Show and Tell"

Lyne T. Barret, used an auger which he fastened to a pipe and rotated by a cogwheel driven by a steam engine. His technique was a basic principle of rotary drilling which is still in use.

In 1867, a well was dug at Oil Springs in the same county and as other wells were brought in, Nacogdoches County became the site of the first commercial oil field in Texas.

It was not until 1894 that Texas had a major oil discovery. A water well being drilled for the city of Corsicana brought in oil instead of water, and the well was abandoned. In 1895, a company drilled several oil-producing wells, and it was there the first well-equipped refinery in Texas was built. The Powell Field near Corsicana was discovered in 1900.

The most famous date in Texas petroleum history is January 10, 1901, when oil gushed from Spindletop, near Beaumont. This was the first salt dome oil discovery, and it was this well which encouraged the exploration and drilling in Texas that has continued since.

The East Texas oil field, biggest of them all, was discovered near Turnertown and Joinerville, Rusk County in 1930. This discovery was followed by the biggest leasing campaign in history. The field extended from Rusk County to Kilgore, Longview and Northwood.

The most important oil discoveries made since that time have been in west Texas in Scurry County, the major one in 1948, which brought about later developments in that area.

Natural gas as a temporary energy source also is a fossil fuel. Millions of years of pressure on organic material has

Are these oil fields still in operation today? Why or why not?

formed a mixture of gaseous hydrocarbons, made up mostly of methane, which is called natural gas. Through combustion, gas releases its stored chemical energy.

Today, the energy and products provided by the basic mineral fuel of crude petroleum and natural gas permeate the economy of Texas.

(2) Coal in Texas

Coal is the most abundant of the fossil fuels. It took nature millions of years to transform organic materials such as trees and other plant life into a hardened or concentrated form called hydrocarbons. The combustion of these hydrocarbons releases its stored chemical energy.

Before oil and gas were used significantly in Texas, coal was an important energy source. Beginning in 1895 and lasting through 1943, more than 24 million tons of coal were produced. The early coal mines have been inactive for many years, but coal is now receiving increased attention as a major source of energy in the state.

Deposits of bituminous coal have been found in north central Texas, which includes Coleman, Eastland, Erath, Jack, McCulloch, Montague, Palo Pinto, Parker, Wise, Young, and nearby counties. Because the coal deposits in north central Texas are no more than 30 inches thick and have a high ash and sulphur content, problems are present for efficient surface mining and land reclamation.

Locate these coal deposits on a Texas map.

In south Texas, bituminous coal was produced in the Eagle Pass area of Maverick and Webb counties during the late 1800s and early 1900s. The thickness there ranges from 4 to 7 feet, and further exploration may be feasible in the future.

It is believed that coal deposits in the Trans-Pecos country of west Texas around Brewster and Presidio counties are not adequate to hold any potential for future development.

Lignite, which is a low-grade coal, is found in two belts in Texas which extend across the Texas Gulf Coastal Plain from the Rio Grande River near Laredo in south Texas to the vicinity of the Arkansas and Louisiana boundaries in east Texas. The greatest amount and the highest grade lignite are found mostly north of the Colorado River in east and central Texas.

Known commercial deposits of lignite are found in Bastrop, Freestone, Harrison, Henderson, McMullen, Milam, Panola, Robertson, and Titus Counties.

There are additional lignite resources on the Texas Gulf Coastal Plain including Bastrop, Fayette, Houston, Lee, Leon and Madison counties. These lignite deposits could be used as potential energy sources for the future.

Three large strip-mines are producing lignite that is burned for electric power generation. These are located in Milam, Freestone, and Titus counties. A large mine is being developed in Panola County, and there will be mines developed in Henderson, McMullen, and Robertson counties.

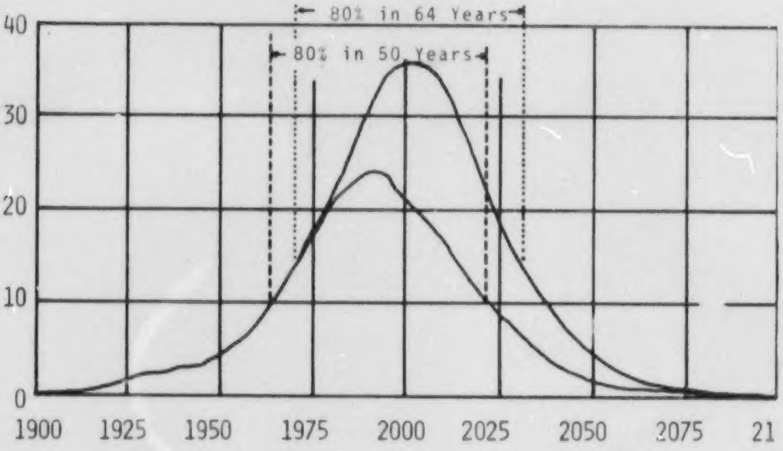
What problems do you see in transporting this source of energy? Is coal historically an easily transportable source of energy?

D. ENERGY DEPLETION RATES

It is important to point out the present heavy dependence on fossil fuels, a finite non-renewable resource, (which means they will eventually be depleted). No matter what additional supplies may be found, no matter what new technologies may be developed that increase recovery, or extend the useful period, fossil fuels are a finite resource and their availability must decrease with time. Figures 1.4 and 1.5 show curves which represent the high and low estimates of possible reserves, recovery, and use of coal and oil in the U.S. In the long run, it makes little difference which of the predictions is correct--the fossil fuels will run out. As more nations (and therefore, more people) become industrialized, the consumption of these easily obtained energy resources will increase markedly and the depletion rates may change accordingly. It should also be noted that coal is a major storehouse of raw organic materials and may rapidly become far more valuable as a chemical source than as a fuel. A similar situation exists for natural gas.

DEPLETION RATES

CYCLE OF WORLD OIL PRODUCTION



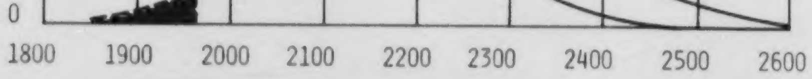
PRODUCTION (10^M BARRELS PER YEAR)

SOURCE: U.S. BUREAU OF CENSUS
AND RESOURCES FOR THE
FUTURE

FIGURE 1.4

DEPLETION RATES

CYCLE OF WORLD COAL PRODUCTION



PRODUCTION (10^M METRIC TONS PER YEAR)

SOURCE: U.S. BUREAU OF CENSUS AND RESOURCES FOR THE FUTURE

FIGURE 1.5

Annual production of natural gas in the United States went from 6,262 trillion cubic feet in 1950 to 22,600 trillion in 1973, then began a decline, reaching 20,100 trillion in 1975. Crude oil production peaked at 3,577 million barrels in 1971, and then declined to 3,356 million in 1973, and 3,052 million in 1975. Coal production has increased, however, from 560 million short tons in 1950 to 598 million in 1973 and 646 million in 1975.

The trend in energy use is clear. Per capita consumption in the United States has risen from 180 million Btu in 1925 to 300 million Btu in 1973. The average per capita figure for the world, by contrast, was 23 million Btu in 1925 and 55 Btu million in 1968. Comparisons between the average American consumer and any other citizen of the world are rather dramatic, as Figure 1.6 demonstrates.

This chart may be the most frightening chart available. Can you name comforts and convenient uses of energy enjoyed in the U.S. which other countries do not enjoy? Your list could be inexhaustible.

HOW MUCH ENERGY DOES EACH PERSON USE IN A YEAR?

AN AMERICAN	300 MILLION Btu/YEAR
A GERMAN	150 MILLION Btu/YEAR
A RUSSIAN	130 MILLION Btu/YEAR
A PUERTO RICAN	100 MILLION Btu/YEAR
A CHILEAN	40 MILLION Btu/YEAR
THE WORLD AVERAGE	35 MILLION Btu/YEAR
A CHINESE	13 MILLION Btu/YEAR
AN INDIAN	5 MILLION Btu/YEAR
A NIGERIAN	1.5 MILLION Btu/YEAR
A NEPALESE	.3 MILLION Btu/YEAR

SOURCE: ENERGY CONSERVATION: UNDERSTANDING AND ACTIVITIES FOR YOUNG PEOPLE

FIGURE 1.6

As per capita energy consumption increased along with electrification, so did inefficiency in energy conversion. The gap between gross and net energy consumed per capita in the United States has risen from approximately 25 million Btu in 1947 to approximately 65 million Btu in 1975. Technical conversion losses have increased considerably, even since the 1973 "crisis," as consumption of natural gas and electricity generation have given way to oil and coal--both less efficient fuels.

In 1968, residential consumption was more than 19 percent of the national total, with commercial use accounting for 14.4 percent, industrial use 41.2 percent, and transportation 25.2 percent. By 1973, the household and commercial sectors together consumed 30 percent of the U.S. total, the industrial sector accounted for 39 percent, and the transportation sector had grown to 31 percent.

The growing gap between domestic production and consumption has led to an increased dependence on imports, especially petroleum. Such products supplied 14 percent of the nation's total energy in 1920, but the figure had risen to 46 percent by 1973. To meet the petroleum demand, imports of relatively inexpensive crude oil from outside the country, especially Venezuela and the Middle East, increased rapidly. Petroleum imports rose from 8 percent of domestic demand in 1947 to 36.8 percent in 1975, and was expected to reach 46.1 percent in 1977 although imports in fact passed the 50 percent mark in 1977. The United States imports roughly 5 percent of its natural gas supply as well. U.S. dependence on foreign supplies came sharply into focus during the Arab oil embargo in the winter

List some of the reasons for these sharp increases in energy use. By recognizing the uses, the student will be able to identify conservation measures later on.

Now that China has been recognized by the U.S., how will this Western culture influence the Chinese per capita energy consumption? Is political ideology connected with or influential on the amount of energy a country uses?

of 1973-74, which created widespread shortages of gasoline and heating fuels.

Prices escalated sharply, then dropped slightly and leveled off, but remained well above pre-embargo levels. The wellhead price of domestically produced crude oil increased 72 percent from 1973 to 1975, and imported crude oil increased even more dramatically. Libyan crude oil, for instance, rose from $3.77 a barrel in January 1973 to $13.71 a barrel in January 1976. Coal prices in 1975 were $16 to $18 a ton free on board (transportation not included) for underground coal and $10 a ton for surface-mined coal, compared with the 1971 average price of $6 a ton. Nationwide, electric utilities paid an average of $18.61 per ton for coal in mid-1976.

The price of natural gas continues to be determined and somewhat confused by the regulatory bodies and long-term contracts that are characteristic of the natural gas business. For 1975 the Federal Power Commission (FPC) set the base ceiling rate to 50 cents per 1,000 cubic feet (MCF) of natural gas that began flowing in interstate commerce after December 31, 1972. This represented an 8-cent increase over the regulated 1974 price. The wellhead price of new gas has since been raised by the FPC to $1.42 per MCF. The average price paid for imported gas entering regulated pipelines increased from 59 cents per 1,000 cubic feet in September 1974 to $1.41 a year later and to $1.80 on January 1, 1977. The price of intrastate gas continued to vary widely. For example, in 1976 1,000 cubic feet of natural gas (at retail) cost $3.01 in Austin, Texas, while in Amarillo, Texas, the same quantity of gas could be purchased for 50 cents.

What are the present prices of oil? How often do they change? What are some of the reasons for oil price changes? Is the situation of oil pricing by oil producing nations a type of blackmail for the rest of the world? Explain.

Why are there such price differences between Amarillo and Austin? (LaVaca Gas Company).

E. THE ENERGY CRISIS

The situation described above, where the supply of energy does not keep pace with the demand, has caused an energy crisis. Actually, three different energy crises are occurring simultaneously in our country and each requires a different solution.

The first type of crisis is the acute crisis. This crisis forces the populace to reconsider building designs, building materials, and the balance of national and individual resources. It is resolved by a progressive improvement in building design and energy consumption, and it requires constant improvement.

The second type of crisis is the chronic crisis. This crisis forces the populace to reconsider building designs, building materials, and the balance of national and individual resources. This crisis can be resolved by a progressive improvement in building design and energy consumption. Solutions to this kind of crisis require constant revision.

The third type of crisis is the terminal crisis. That is the ultimate situation when all fossil fuel is depleted. The solution is to realize it will happen and to be prepared to switch to alternate energy sources and self-sufficiency. The social and political implications of this crisis are frightening if intelligent steps of preparation are not taken. Figure 1.7 summarizes these three crises.

How does each of these crises effect the average American citizen in the home?

THREE TYPES OF ENERGY CRISIS

TYPE OF CRISIS	CONSEQUENCE	ACTION
ACUTE	NATIONAL BANKRUPTCY	TURN DOWN OR SWITCH OFF
CHRONIC	HIGH ENERGY COSTS REQUIRING ADJUSTMENT IN BALANCE OF USE OF BOTH NATIONAL AND INDIVIDUAL RESOURCES	DESIGN BUILDINGS TO BE THERMALLY EFFICIENT
TERMINAL	EXHAUSTION OF FOSSIL FUELS	DEVELOP ALTERNATIVE AND RECYCLABLE SOURCES OF ENERGY

SOURCE: PETER BURBERRY, BUILDING FOR ENERGY CONSERVATION, 1978.

FIGURE 1.7

Of major concern is the failure of the United States to take significant steps to reduce energy consumption. The U.S. wastes billions of energy units daily while other nations are going without. The industrial nations of the world have 30 percent of the world's population but use 80 percent of the energy. The U.S. has only 6 percent of the world's population but uses over one- third of the energy consumed in the world. Figure 1.6 showed that an American uses as much energy for air conditioning as China uses in total, and China has four times our population. India, with 15 percent of the world's population, uses only 1.5 percent of the world's energy; or each American consumes as much energy as do 60 residents in India. Energy use and consumption of natural resources might be better balanced if the United States practiced strict energy conservation measures and used renewable energy sources.

Does the worldwide concern about the U.S. attitude toward energy use affect the value of the U.S. dollar on foreign money markets? Can the sudden surge in the value of the German mark, Swiss franc, and Japanese yen have any relation to their efficiency rate of energy use?

MODULE I

AWARENESS OF THE ENERGY DILEMMA

UNIT II

RENEWABLE/ALTERNATE ENERGY SOURCES

UNIT OBJECTIVES

1. Recognize alternate sources of energy used and proposed for today's use.
2. Understand some of the problems related to these alternate sources of energy.

MODULE I

AWARENESS OF THE ENERGY DILEMMA

UNIT II

RENEWABLE/ALTERNATE ENERGY SOURCES

LECTURE

INTRODUCTION:

Finding alternate sources of energy to replace some of the oil used daily and cutting down in some areas could help restore the economy to a sound position. Restoring the economy is a good motive for conservation, but everyone should be motivated by something even more important to the development of the country and of the world--the rapidly dwindling natural resources. A world without energy resources will not happen tomorrow, and those living today may not be around to see it, but their grandchildren might be. Future generations will certainly feel the results of negligence and selfishness unless measures begin right now to conserve energy and search for sound solutions to today's wasteful use of energy.

A. BIOMASS CONVERSION

Wood is one renewable energy source. By carefully planning our use of the forests, and by replanting fast-growing species whenever cutting is done, the supply of lumber for future needs and the construction industry should be adequate. Though it will not be possible to count on wood for burning as a replacement for coal and other fossil fuels, other sources could be supplemented with wood.

ACTIVITIES

TURNING TRASH INTO USEABLE ENERGY

THINGS YOU NEED:

Household trash (see text). A shallow baking dish. Aluminum foil.

As we said earlier, many of the things we throw away every day can be burned to produce heat. They are a source of energy. This simply experiment proves the point. It shows one way of converting trash into fire fuel.

One hundred years ago, over 75 percent of America's energy was from burning wood. Today less than one-third of 1 percent of the nation's energy comes from wood. However, 4.6 million tons of residential, commercial, and industrial solid waste is wood accumulation. This is three-fourths as much as is used yearly for wood products.

A 6- to 12-acre lot of land could produce enough wood to heat one home indefinitely. Hardwood has one-half the heat value of coal and one-third that of oil; soft wood has less. Plants and wood wastes can be turned into methane which can in turn supply a family with fuel for cooking and lighting. One ton of solid waste, which includes wood and wood by-products, yields 10 million Btu. If incinerated to generate electricity, 10 percent of 1970s solid waste in the U.S. could have yielded 25 billion kilowatt hours, or 1.5 percent of the U.S. electricity production that year.

The first step is to put on a pair of gloves and rummage through your trash cans. Look for paper or cardboard items (that aren't too dirty or messy). For example:

-Can labels
-Cardboard boxes
-Paper cups or plates
-Toilet tissue wrappers
-Paper towels
-Flour or sugar bags

You get the idea...the list can go on and on.

Using scissors, cut these items into pieces that will fit neatly into the baking dish. But don't put them into the dish yet. First, soak them in water until they are soggy. While the paper pieces are soaking, line the dish with aluminum foil to keep it clean.

Then place layer after layer of soggy paper into the dish. Use your fingers to press the layers together and to force the excess water out of the soggy mass. Pour this excess water out. Stop adding layers when you've built a pile that's about 3/4" thick.

Now we want the compressed pile to dry out. For this demonstration only, let's speed up the drying process. Let's use an over (better check to see if it's okay to use the oven for this purpose). bake the pile for about an hour. Oven temperature should be around 200°F. DON'T USE A MICROWAVE OVEN. Because of the aluminum foil, the microwave tube inside the unit could be damaged.

After taking the dish out of the oven and after the contents have cooled, lift the pile out of the dish. If it is still damp, set it aside until completely dry. When dry, chunks of this salvaged waste paper will burn like wood. You can use them in a fireplace, campfire, or whatever.

When making additional piles, skip the oven part. (You don't need the baking dish either; use something else.) Simply let the piles dry outside in the aluminum foil liner. It doesn't make sense to consume more energy using the oven than you get from the fire fuel.

B. SOLAR ENERGY

Solar power is a source of energy that is being tapped with renewed interest. There are special construction and building specifications that must be followed for solar power, and in certain areas of the nation where the sun does not shine for extended periods in winter, supplemental power must be called upon to fill the energy needs.

There are no major technological barriers to using solar for heating water, space heating, and air conditioning. Turning the sun's energy into electricity through photovoltaics is possible but expensive at present. With the emphasis government is placing on this source and tax incentives which have been enacted, solar could furnish a large portion of the nation's energy needs by the 1990s.

Solar energy is nonpollutant and generally available to everyone. Its use is not new, dating back to 770 B.C. in Rome when solar reflectors were used to light the sacred fire in the Temple of Vesta Today solar is used extensively in Japan, Israel, and Australia; in the 1920s solar hot water heaters were used in Florida, Arizona, and New Mexico. Presently it is a competitive and conventional energy source for space heating in the Canadian border states of the extreme northeast and north central regions of the U.S.

A MODEL SOLAR HOT WATER HEATER

THINGS YOU NEED:

-- About 10' of flexible black tubing.
-- A shallow cardboard or wood box about 12" by 18".
-- Flat black paint, paper, or cloth to line the box.
-- A piece of window glass to cover the box.
-- A spring-type wooden clothespin.
-- Tape.
-- Two empty cans or buckets.
-- Thermometer.

The experiment will help you understand how solar hot water heaters operate.

You can easily build a model solar energy collector. Start by covering the inside of the box with black paint, paper, cloth, or other dark material. Then loop the tubing back and forth inside the box. Arrange for both ends of the tubing to be sticking out of the sides of the box a couple of feet.

Next, place the glass cover on the box and secure it with tape. It is ready for a test.

Wait for a sunny day and find an open area. Place the collector on a stand, with a can or bucket of water next to the collector. Put one of the tubing ends into the water. Suck gently on the other end to establish a siphon action. Once water starts to flow through the tubing, pinch the tubing partially with the clothespin to

Between 1980-1985, it will become feasible in the middle belt states, and after 1985 in the southern sun belt states.

C. WIND ENERGY

Wind power is being tested in several areas again, but wind is not dependable. It does not blow all the time and allowances must be made for adjusting to the strength of the wind. Wind is one servant that may turn on its users in the form of tornadoes, cyclones and hurricanes, and destroy the equipment needed to channel its use.

limit the flow of water to a small trickle.

Notice that after a while, the water trickling from the tubing will be warmer than the water siphoning into the collector. Test the temperature of the water.

How warm the water gets will depend mostly on the time of year, how clear the skies are, and how slowly the water flows through the collector.

Once the bucket is a quarter full of warm water, replace the bucket of cold water with this bucket, and set an empty bucket as a collection container. Take the temperature of the water. How many degrees did it rise?

Although wind energy is clean and appears to be free, many problems remain to be solved:

-- The wind-powered generators available today are expensive.

-- They are large.

-- They don't generate electricity unless the wind is blowing, obviously.

-- It is costly to store excess energy--that is, energy generated but not immediately needed.

For those reasons, experts believe that wind generators will be useful only in limited situations.

CONVERTING WIND ENERGY INTO ELECTRICITY

THINGS YOU NEED:

- Model airplane propeller about 6" long.
- Two nails 1" long.
- Two nails 3" long.
- Four small nails.
- Small bar magnet 1" long.
- Two metal strips 1 1/2" by 4", cut from a tin can.
- Magnet wire.

Wind power is one of the world's oldest energy systems. Through the times of Thomas Jefferson, the only important source of industrial power other than the water wheel was a windmill. By 1900, a large windmill industry existed in the United States, with a capital investment of over $4 million. By the 1920s, wind power had become a major source of electrical power on farms and homesteads across the United States. These small-scale generators served well for years, providing cheap, clean electrical power to thousands of rural and farm homes. However, the establishment of the Rural Electrical Administration (REA) in 1930 made federally subsidized, centrally generated electrical power available to farms.

The two major problems with wind power are costs and storage: How do you keep the lights on when the wind stops blowing? There are several storage technologies. The most familiar is lead-acid batteries which can be charged while the wind is blowing and then used later. Unfortunately, these can cost as much as the wind machine itself. Another alternative is to use pumped water or air--either pump water up into a reservoir and then let it fall to turn the turbines as needed (as is presently done with many conventional power plants), or use the wind machine to compress air that can be stored in tanks or natural caverns and then fed into gas turbines as needed. Cost of wind power generators should be competitive with fossil fuels and nuclear plants when the components are mass-produced. Low maintenance and zero fuel costs make this machine attractive for future development.

-- Germanium diode type 1N23A (most electronic stores carry this inexpensive part).
-- Tape.
-- Glue.
-- Soldering iron and solder.
-- Wood block about 3 1/2" by 5".

This model wind generator works much like the new "wind turbines" for generating electricity. When the propeller spins, the magnet whizzing past the nail head generates a tiny alternating current(AC) in the coil wound around the nail. The small germanium diode connected across the two nail terminals converts the AC into direct current (DC), which is what is needed in this experiment.

To make the wind generator, begin by wrapping 1,000 turns of magnet wire around one of the large nails. The coil should be 2" long, measured from the head end. Leave a few inches of wire for connections. Twist them so they won't unravel.

Drive this nail into the center of the wood block. Also drive in th two smaller nails where shown.

After scraping the enamel insulation off the ends of the coil wires, wrap the bared ends around the nail heads. Then hook the diode across the nails, and make all connections secure by soldering.

Next, glue the bar magnet to the head of the other large nail. Be sure the magnet is centered on the head and the glue is given plenty of time to set. This will be the propeller shaft.

The shaft is supported by the two tin-can strips. Fold the tin strips in half lengthwise for added stiffness, then bend about 3/4" for the base. Nail them to wood block, in line with the upright nail.

Insert the shaft in the supports until the magnet is directly over the nail head. Two collars of electrical tape will keep the shaft in place. Finally, drill a hole in the propeller so that it fits snugly on the nail.

Now for the test: Connect the galvanometer's alligator clamps to the two nail terminals. Keep the compass about a foot away from the magnet. Have the galvanometer coil lined up with the compass needle.

Set the generator in the wind or in front of a fan. (Or wrap a couple feet of string around the shaft and pull upward, like trying to start a power lawn mower.) When the shaft turns, you'll see the compass needle deflect. This demonstrates that electricity can be produced from the wind.

D. OCEAN SOURCES

(1) Ocean Thermal Energy Conversion

Since the 1820s, mechanical engineers have been building heat engines based on the concept that mechanical energy can be extracted from the flow of heat energy between a hot and a cooler region. The oceans' heat is of solar origin. In tropical latitudes the water surface has a relatively constant temperature, close to 80°F, but at 3,000 or more feet below sea level, the temperature drops to the low 50's. Although small, this 35°F differential constitutes the elements of a heat engine.

An Ocean Thermal Energy Conversion (OTEC) power plant would operate a heat engine by utilizing the energy that can be made to flow between the warm solar-heated surface water of tropical and subtropical oceans, and the deep, underlying colder water. A working fluid, such as

THE IDEA BEHIND OCEAN THERMAL ENERGY CONVERSION:

THINGS YOU NEED:

-- An empty narrow-mouth plastic bottle.
-- A balloon.
-- A bucket filled with hot water.
-- Another bucket filled with cold water.

Put the empty bottle and balloon in a refrigerator. Leave them there for at least one hour (they both must be cold).

Before removing the bottle and balloon from the refrigerator, prepare the buckets of hot and cold water. Add a handful of ice cubes to the cold water to make it even colder.

Taking the balloon in your hand, squeeze it to drive out all air. Then quickly slip the neck of the balloon over the mouth of the cold bottle.

propane or ammonia, would be vaporized by the warm surface water, the pressurized vapor would turn a turbine, and the cycle would be completed by using the cooler water to condense the gas back to a liquid. The laws of thermodynamics act to make this a very low efficiency machine, but the consistency of the temperature and the availability of unlimited volumes of water at the surface and at depths give this machine immense energy potentials. A demonstration plant could be testing ocean thermal energy equipment in an ocean environment by the mid to late 1990s. Present U.S. Electrical production capacity is 500,000 Mw.

Immerse the bottle in the hot water (it's okay if the balloon is in the water too). In a few moments, you'll see the limp balloon begin to inflate.

When the inflation stops, immerse the bottle in the cold water. The balloon will slowly shrink and become limp again.

Repeat the hot and cold immersion steps.

This experiment shows that heated water expands a working medium (the air inside the bottle) and makes it do "work" (blow up the balloon slightly). Cool water restores the medium to its original volume so that it can work again when reheated.

The experiment also demonstrates the principle of operation of a real ocean thermal energy conversion system--the heated liquid turns into an expanding gas, which "works" by turning the turbine. When cooled, the gas condenses back into a liquid, shrinking in volume.

A power plant uses ammonia as the working medium (Note: this is not the same as household "ammonia", which is really ammonium hydroxide). The process begins with the ammonia in liquid form, at a temperature of 40 F.

1. Warm seawater at the surface heats the liquid ammonia to a temperature of 80°F. This heating turns the ammonia into an expanding gas.

2. The expanding gas rushes the turbine, making it spin. The turbine is connected to an electric generator. As the turbine spins, so does the generator, thus producing electricity.

3. Cool seawater, from the deep, chills the ammonia gas and turns it back into a liquid.

4. Same as step 1...the cycle starts all over again.

Although this process could generate much electricity, building a large ocean thermal energy conversion plant would be very difficult and expensive. Still, the concept holds promise in the warm parts of the world.

This simple experiment uses air as the working medium to demonstrate the principle on which ocean thermal energy conversion is based.

(2) Tidal Generators

In some parts of the world, it's possible to harness the ocean's tides to make electricity. The idea is simple: First, build a dam across a bay. Then use the water that "piles up" against the dam to turn electric generators.

During high tide, the water builds up on the ocean side of the dam. It is allowed to flow into the bay by passing through turbines that turn electric generators.

During low tide, things are reversed. Now, the water trapped on the land side of the dam again passes through the turbines as it flows back to the ocean.

Two tidal energy conversion plants have been built overseas. They prove that the idea works, but not all bays are suitable for this kind of energy conversion process. In fact, there are only about a dozen places in the United States where this kind of power plant could be built. The tides must be high enough to create a worthwhile difference in water height. And the bay must be narrow enough for a practical dam to be built.

E. GEOTHERMAL

Imagine the earth as an orange, and the orange rind as the only really cool part of the earth on its surface; the remainder of the orange represents very hot liquid rock which is a tremendous heat source. Geothermal energy--the heat deep inside the earth--is a vast potential source of useful power which should become available for a wide variety of important applications as economic exploitation technologies are developed. This internal energy of the earth is thought to be the result of the natural decay of radioactive materials. Thus, it is virtually inexhaustible, although the heat content of a particular reservoir might be depleted after several decades of active use.

Theoretically, such energy could be obtained at any point on earth by drilling deeply enough and providing some arrangement for extracting the heat. In most parts of the world, the hot interior mass is too deep to reach with existing drilling technology, but in some areas, including many places in the western U.S., large heat sources occur close to the surface. The exact locations and sizes of these sources are not yet completely established.

GEOTHERMAL ENERGY

The United States has 1.8 million acres of land where geothermal energy is known to exist in various forms. This leads to the belief that geothermal energy may eventually become an important source of electricity. Some estimates indicate that 30 percent of our electricity will come from geothermal energy by the 21st century.

GEOTHERMAL STEAM ENGINE

THINGS YOU NEED:

-- An empty soup can
-- Heavy aluminum foil (frozen food tray, pie pan, etc.)
-- Aluminum wrapping foil
-- Straight pin
-- An 8" length of still wire (coat hanger)
-- Stick about 12" long
-- Small pot
-- Glue
-- Tape
-- Rubber band

With a little imagination and a model turbine, you can get some idea how steam can produce electricity. First, you'll have to build the model.

1. If not already off, remove the lid from the soup can. Rinse out the can.

2. Turn the can upside down and punch two 1/8" holes opposite one another in the bottom. Locate each hole about 1/4" away from the rim.

3. From your frozen food tray or pie pan, cut out a flat disk equal in diameter to that of the can. Pierce a hole in the center of the disk with a straight pin.

4. Take some aluminum wrapping foil and wad it up into a little ball the size of a small cherry. Glue this ball to the disk, centered right over the hole. It will prevent the disk from wobbling badly.

5. After the glue has dried, put the pin in the disk hole and push it through the ball. Try to get the pin as perpendicular to the disk as you are able. Now enlarge this hole slightly with a thicker pin or needle. The idea is to have the disk and ball spin freely on the pin.

6. Make eight equally spaced "pie cuts" in the disk with a pair of scissors. Cut all the way to the ball.

7. Twist each "pie wedge" slightly to form the turbine wheel.

8. Bend the still wire, as shown. Make sure that when the wire is later attached to the can, the small downward segment will point to the can's center.

9. Slip the straight pin through the turbine and tape it to the support wire. Then tape the support wire to the can so that the turbine is as close as possible to the can without touching it. Blow on the turbine to test it. It should spin quite easily.

10. Fasten the stick to the can with a rubber band or string.

11. Now for the steam. Put a cup or two of water in a small pot. Before heating the water, cover the top with aluminum foil, pinching the edges all the way around. Make a pencil-sized hole in the center.

12. Bring the water to a boil. When steam starts jetting from the hole, lower the can over the hole, using the stick as a handle. The steam pouring from the two holes in the soup can will start the turbine spinning merrily.

F. NUCLEAR

(1) Conventional Reactors

Regardless of how they are fueled, most generators function in much the same way. Basically, heat is used to boil water into high pressure steam. The steam passes through the blades of a turbine, causing the shaft on which the turbine blades are attached to turn. The rotating part of the electrical generator is on the same shaft so it spins along with the turbine, generating electricity. The spent steam is condensed to water and returned to the steam generator.

In a fossil power plant, either coal, oil, or gas are burned in a furnace to boil water to steam. In a nuclear plant, the furnace is replaced by a reactor which produces heat through a chain reaction of the nuclear fuel. This chain reaction is regulated at all times with control rods, which stop the fission process when completely inserted into the reactor core. The nuclear fuel most commonly used today is uranium-235, which occurs in nature. In a nuclear reactor, the fuel atoms fission (that is, they split apart), and this process releases tremendous quantities of heat to make electricity.

The technology necessary to build nuclear plants is well established. Currently, there are about 70 power reactors operating in this country and they are supplying more than 10% of our electricity. That's the equivalent of burning one million barrels of oil every day. Nuclear power is growing; it now supplies twice as much electricity as it did two years ago, and its contribution is expected to increase. In the year 1985 it is projected that 125,000 Ms of nuclear generating capacity will

You'll have to imagine that in an actual power plant, high pressure steam blasts against a series of such turbine wheels on the same shaft. The shaft, in turn, drives an electric generator, which produces the electricity. It's amazing how powerful steam is.

be in service and will produce 665 billion KWH that year. If this were to be generated instead of fossil fuel generating plants, the equivalent of 2.75 million barrels of oil would be required each day.

One common question asked about nuclear power is: Is it safe? One need only examine the nuclear safety record of the industry. With over 300 commercial and 1,300 naval reactor-years of operation, no member of the public has ever been injured or killed by a nuclear power plant.

(2) Breeder Reactors

When conventional fuels such as wood, coal, oil, or gas are burned, their energy is used up and cannot be renewed. Imagine, however, "burning" a fuel that actually creates a greater supply of fuel than is consumed. This can be done in Breeder Reactors, a kind of nuclear "furnace" now being developed. It is called a "breeder" because it produces more fuel--in the form of plutonium--than it consumes.

Actually, the breeder reactor is not a new idea. The liquid metal fast breeder reactor has been under development for over 25 years. In fact, the first electricity produced by nuclear power was from a reactor of this type--the Experimental Breeder Reactor I--in Idaho in 1951. Unfortunately, the breeder development is faced with a dilemma. The plutonium fuel needed for breeder reactors could also be used for nuclear explosive devices. For this reason the United States is seeking a better approach to the next generation of nuclear power than is now provided by the plutonium breeder.

Discuss these questions as they relate to your community.

What are the trade-offs involved in developing nuclear as an alternate source of energy?

(3) Nuclear Fusion

Fusion is a nuclear reaction. It is, in a sense, the opposite of fission. The release of energy in fission occurs because a large nucleus (uranium, for instance) is split into two smaller ones. In the fusion reaction two very small nuclei combine to form a larger one. In both cases, the mass of the end product(s) is less than the mass of the original reacting nuclei and this lost mass is converted into energy.

The fusion reaction was first scientifically demonstrated and studied 45 or so years ago. It has glimmered brightly for almost 30 years, giving hope for a return to the Eden of abundant energy. But to date, the only man-made, self-sustaining fusion reaction has been the explosion of a "hydrogen bomb."

Fusion uses "fuels" which are essentially inexhaustible. It appears to be relatively benign environmentally and safe. It does not (unless it is designed to do so) produce materials which can be side-tracked for bomb making. Only solar energy, in fact, can compete with its promise. But the achievement of this promise, on a commercial scale, is surely the most difficult technical task that our species has yet undertaken. Many more years of research and development will be required before fusion power plants will be a practical validity.

G. OIL SHALE

In addition to coal-based synthetics, the United States has the option of utilizing additional fossil solids in the form of oil shale and tar sands. Oil shales are misnamed in that they do not contain oil but rather kerogen, an organic material that must be extracted from mined rock. The shale is found in the Green River Formation in Colorado, Utah and Wyoming. These oil-bearing rock formations have been heralded as the answer to America's energy crisis with ringing statements that the potential is measured in thousands of billions of barrels of oil. However, the feasibility of extracting the oil from the rock depends on many factors: the oil content of the rock, its accessibility, and the thickness of the deposits.

Oil shale contains much less energy than coal; thus, incredibly large amounts must be extracted and processed, causing various environmental difficulties.

H. TAR SANDS

If oil shale may be termed the forbidden fruit of the Rocky Mountains, there is an even more sequestered solid fossil fuel in the form of a bitumen called tar sands. U.S. resources in this category may approach 30 billion barrels of locked-in oil, but this source cannot now be considered economical. The tar sands are found primarily in Utah where the deposits range from a few feet to several hundred feet in thickness. Unlike oil deposits, these tar sand reservoirs have little, if any, energy to drive the hydrocarbon from the formation, so it must be removed mechanically and recovered by hot water extraction. Again, the requirement for water is a limiting factor in the possible exploitation of this fuel resource. Farther to the north in Alberta, Canada, the Athabascan deposits are estimated to contain 400 billion barrels of oil, of which 27 billion barrels have a 100-foot

Texas should be ripe for tar sand exploration. Are you familiar with this process going on in the state?

overburden, with an equal volume to be found at or above a 250-foot depth. Huge earth-moving operations are involved in getting at the tar sands, and progress has been slow in winning this fuel resource from the earth. One U.S. oil company pulled out of the Athabascan tar sand project after investing more than $100 million in the activity.

I. PROBLEMS

Some current problems in utilizing certain potential energy sources include the following:

- A controlled, continuous fusion reaction (which would assure an abundant supply of energy) has not yet been produced.
- The energy costs of extracting oil from tar sands and shales and the environmental impact of any such activity make this energy source almost impossible to tap in the near future.
- The technological problems involved in developing ocean or thermal energy place this energy source far in the future as a common and abundant source of energy.

Much research is being done in each of these areas but it is not concentrated in any one area or funded by any central organization. Each research institute concentrates on its particular interest. Many organizations are working at odds because they do not have one common goal. Some are concerned with preserving the environment at any cost; some want to open federal lands to mining and other development. The free and democratic society of the U.S. has actually encouraged the greatest waste of resources that takes place in the world today.

Discuss these questions as they relate to your specific area of residence.

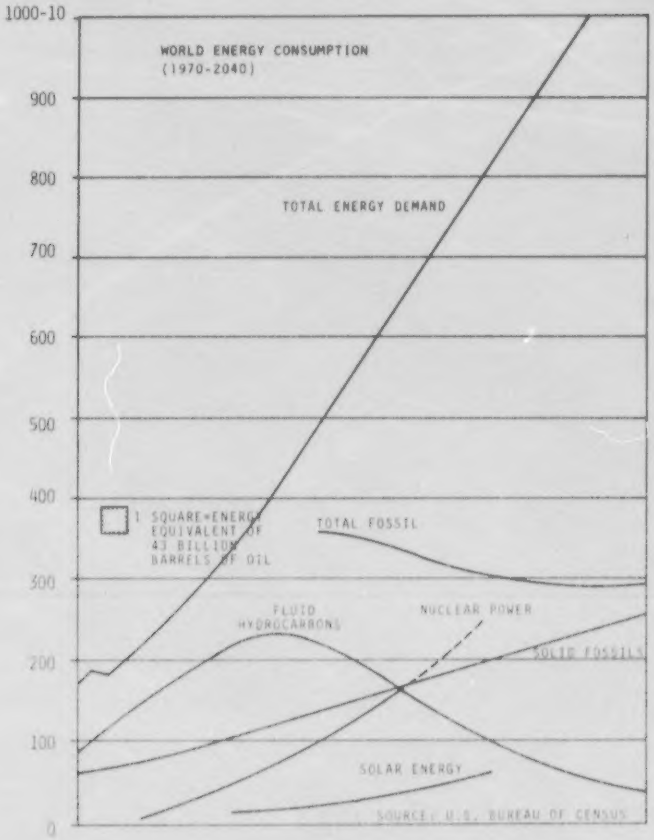
What are the trade-offs involved in developing some of these alternate sources of energy?

What are the economic implications to utility companies, auto industries, gasoline companies, etc? Why is Texas not developing solar energy or other alternate sources of energy faster than is being done? It is not because Texas does not have sunshine.

SUMMARY

Faced with the reality of depleting fossil fuels, all reasonable conservation techniques must be applied in an effort to use present energy resources more efficiently in order to extend the useful period of these fuels until alternative sources can be developed.

Figure 2.1 shows world energy consumption through the year 2040. With oil supplies peaking about 1995, the sharpest rise in energy supply will have to come from nuclear power and solar energy. Alternative energy sources must be developed. Geothermal, wind, and ocean sources are just some of the more promising ideas being discussed today.



SOURCE: U.S. BUREAU OF CENSUS

FIGURE 2.1

MODULE I

AWARENESS OF ENERGY DILEMMA

POSTTEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. In _______ the United States imported about 50 percent of the total oil consumed.

   a. 1930
   b. 1958
   c. 1977
   d. 1979

2. Oil production has been declining in the United States since 1950.

   a. true   b. false

3. Fire was the first external source of energy that people used to aid them in their work.

   a. true   b. false

4. About 95% of the energy that is supplied for our use comes from fossil fuels.

   a. true   b. false

5. The major fuel source available in 1850 was petroleum.

   a. true   b. false

6. Our energy consumption has increased by 400 percent since 1950.

   a. true   b. false

7. Australia is the site of more than 60% of the world's oil reserves.

   a. true   b. false

8. About 1/3 of our nation's energy needs are supplied by:

   a. coal
   b. wood
   c. natural gas
   d. petroleum

9. Nacogdoches County was the site of the first commercial oil field in Texas.

   a. true   b. false

10. Which of the following fossil fuels is the most abundant?

    a. coal
    b. petroleum
    c. natural gas

11. Which of the following is a renewable energy source?

    a. wood
    b. coal
    c. petroleum
    d. natural gas

12. Today, one can use solar energy to produce electricity inexpensively.

    a. true b. false

13. Over 100 acres would be required to produce enough wood to heat one home for an indefinite period of time.

    a. true b. false

14. The technology for nuclear fusion has not been developed to the point that it can be used on a commercial scale to produce electricity.

    a. true b. false

15. It is practical to use nuclear plants to produce energy for our everyday needs.

    a. true b. false

16. The major source of energy in the United States in 1900 was:

    a. coal
    b. wood
    c. natural gas
    d. petroleum

17. It is not now practical to depend upon wind energy alone to produce the electricity we require for our homes.

    a. true b. false

18. Solar energy has been used to heat water on a commercial basis since 1910.

    a. true b. false

19. No pollution is associated with the use of solar energy.

    a. true b. false

20. A German uses more energy annually than an American.

    a. true b. false

MODULE I

AWARENESS OF THE ENERGY DILEMMA

ANSWERS TO POSTTEST

1. c. 1977
2. b. false
3. a. true
4. a. true
5. b. false
6. a. true
7. b. false
8. c. natural gas
9. a. true
10. a. coal
11. a. wood
12. b. false
13. b. false
14. a. true
15. a. true
16. a. coal
17. a. true
18. b. false
19. a. true
20. b. false

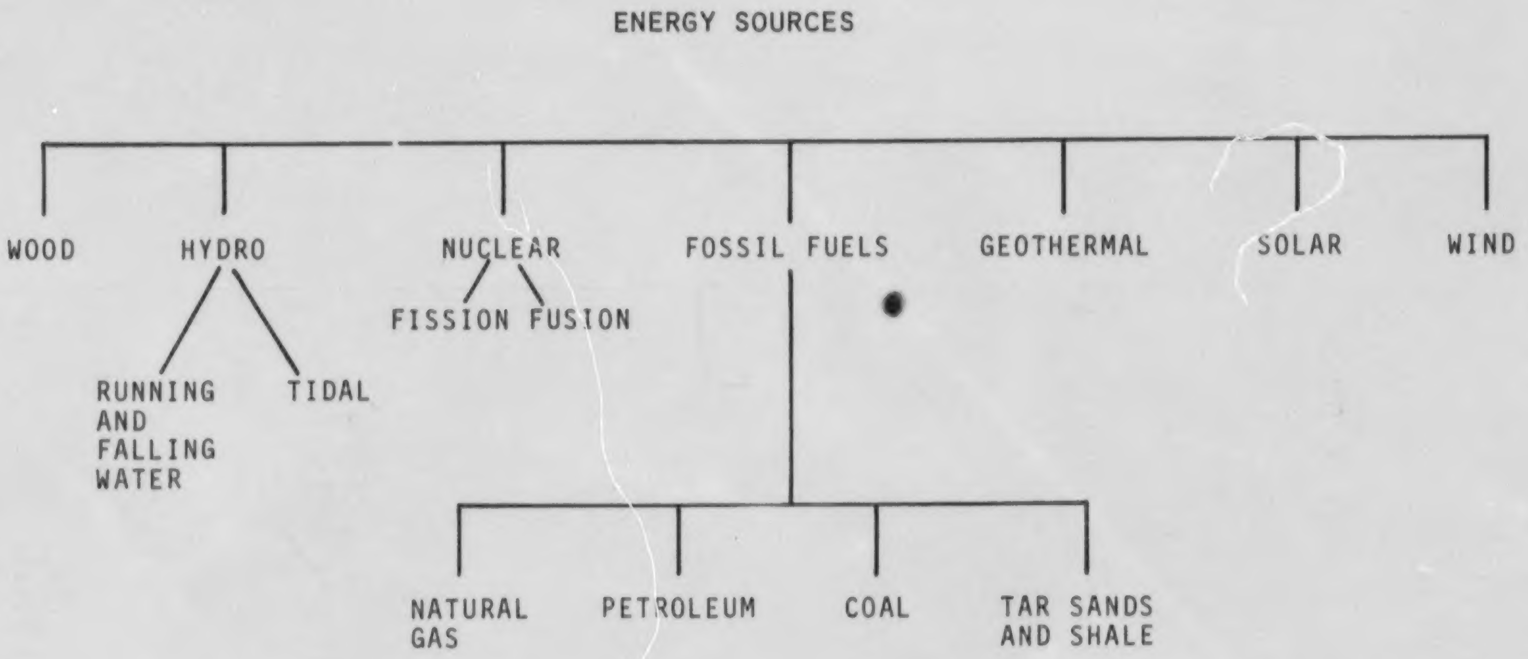
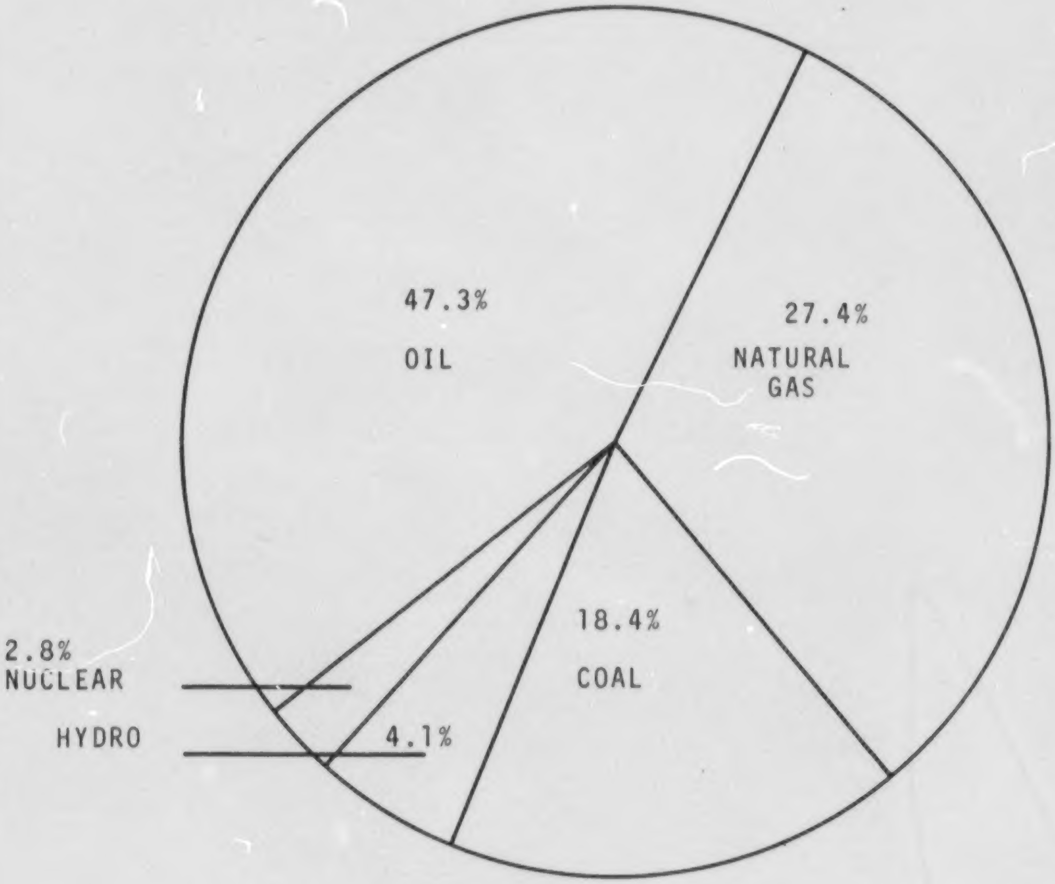

ENERGY SOURCES
WOOD
HYDRO
NUCLEAR
FOSSIL FUELS
GEOTHERMAL
SOLAR
WIND
RUNNING AND FALLING WATER
TIDAL
FISSION
FUSION
NATURAL GAS
PETROLEUM
COAL
TAR SANDS AND SHALE

FIGURE 1.1

HOW U.S. ENERGY NEEDS ARE SUPPLIED

HOW MUCH OF OUR ENERGY COMES FROM EACH SOURCE?

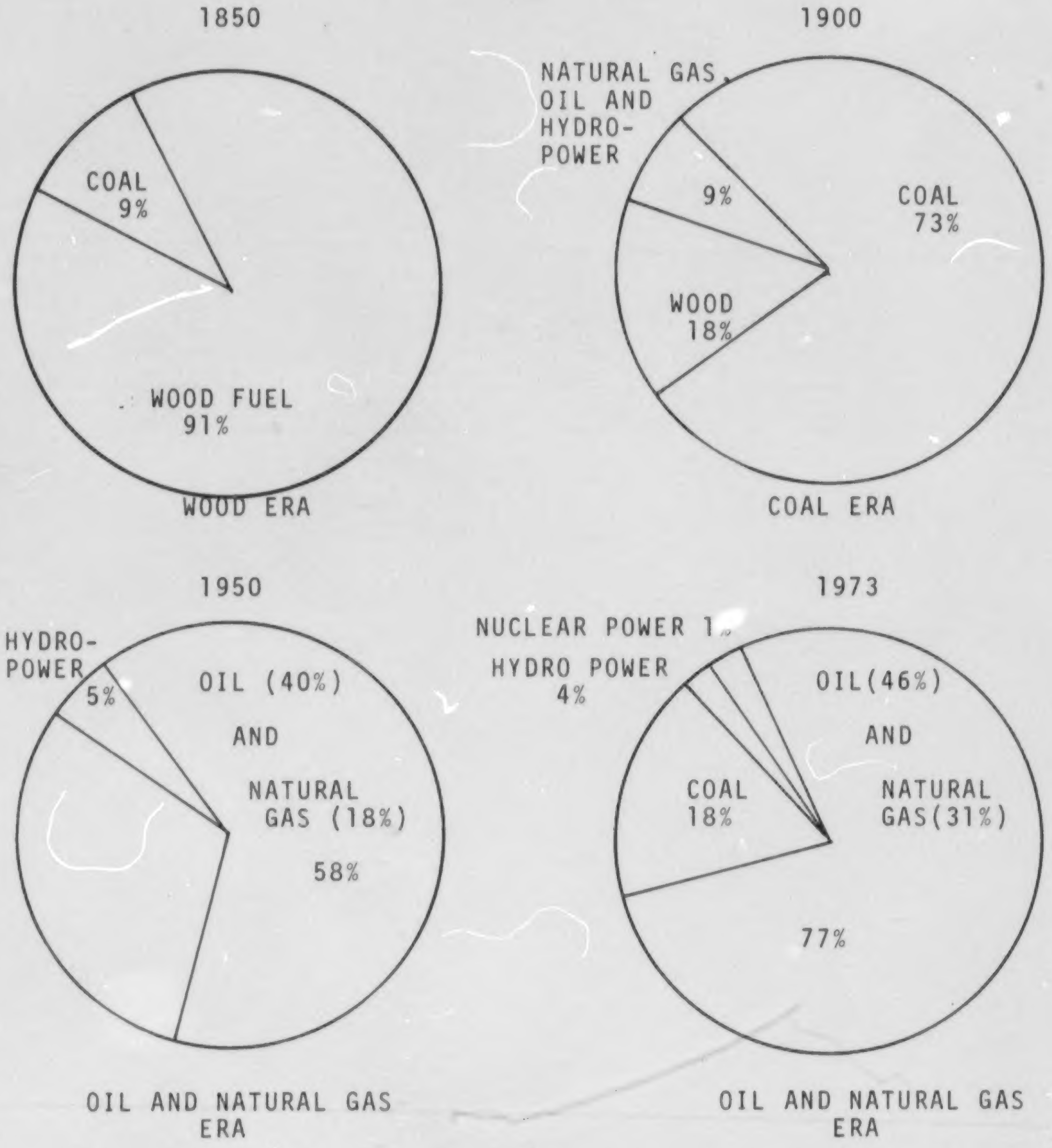


U.S. TOTAL ENERGY SUPPLY

SOURCE: CREATING ENERGY CHOICES FOR THE FUTURE.

FIGURE 1.2

CHANGING PATTERNS IN THE USE OF ENERGY RESOURCES IN THE UNITED STATES



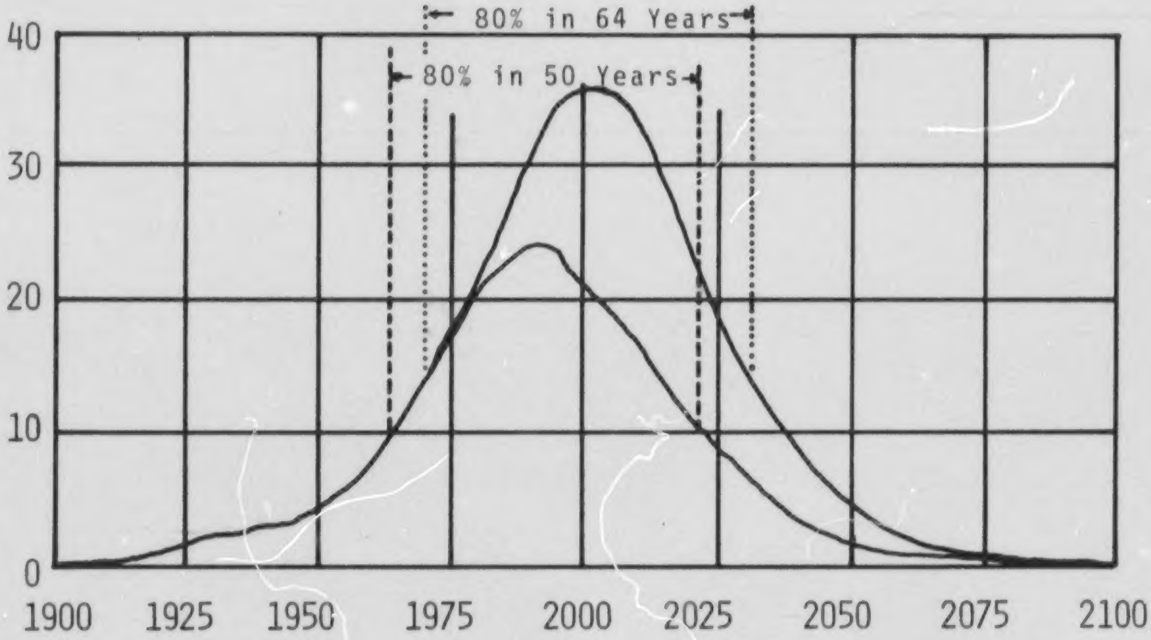
What will the year 2000 bring? NUCLEAR FISSION ERA? NEW COAL ERA? NUCLEAR FUSION, GEOTHERMAL, SOLAR, WIND ERA? ENERGY CONSERVATION ERA? LOWER PER CAPITA ENERGY USE?

SOURCE: U.S. BUREAU OF CENSUS AND RESOURCES FOR THE FUTURE

FIGURE 1.3

DEPLETION RATES

CYCLE OF WORLD OIL PRODUCTION



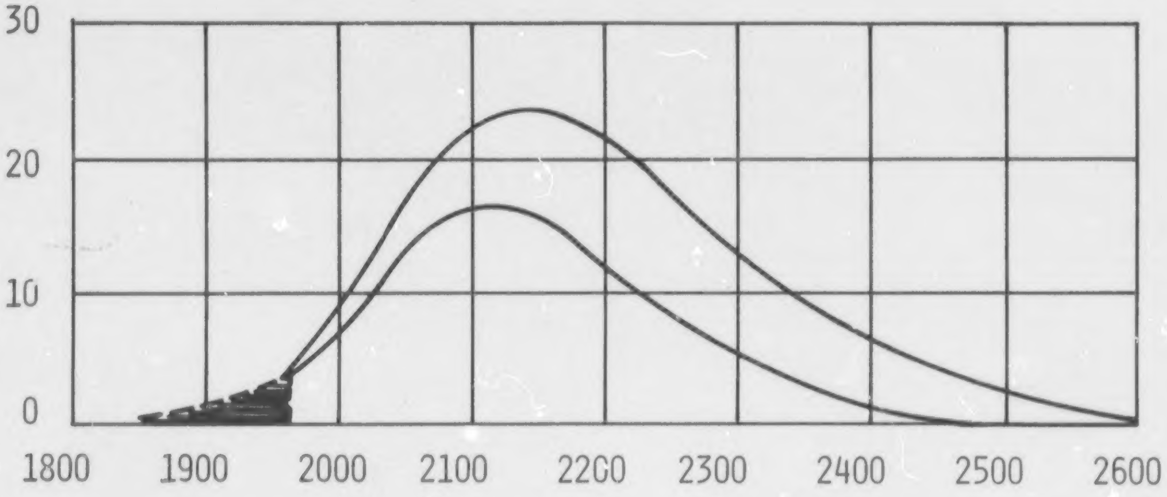
PRODUCTION (10^M BARRELS PER YEAR)

SOURCE: U.S. BUREAU OF CENSUS
AND RESOURCES FOR THE
FUTURE

FIGURE 1.4

DEPLETION RATES

CYCLE OF WORLD COAL PRODUCTION



PRODUCTION (10^M METRIC TONS PER YEAR)

SOURCE: U.S. BUREAU OF CENSUS AND RESOURCES FOR THE FUTURE

FIGURE 1.5

HOW MUCH ENERGY DOES EACH PERSON USE IN A YEAR?

AN AMERICAN	300 MILLION Btu/YEAR
A GERMAN	150 MILLION Btu/YEAR
A RUSSIAN	130 MILLION Btu/YEAR
A PUERTO RICAN	100 MILLION Btu/YEAR
A CHILEAN	40 MILLION Btu/YEAR
THE WORLD AVERAGE	35 MILLION Btu/YEAR
A CHINESE	13 MILLION Btu/YEAR
AN INDIAN	5 MILLION Btu/YEAR
A NIGERIAN	1.5 MILLION Btu/YEAR
A NEPALESE	.3 MILLION Btu/YEAR

SOURCE: ENERGY CONSERVATION: UNDERSTANDING AND ACTIVITIES FOR YOUNG PEOPLE

FIGURE 1.6

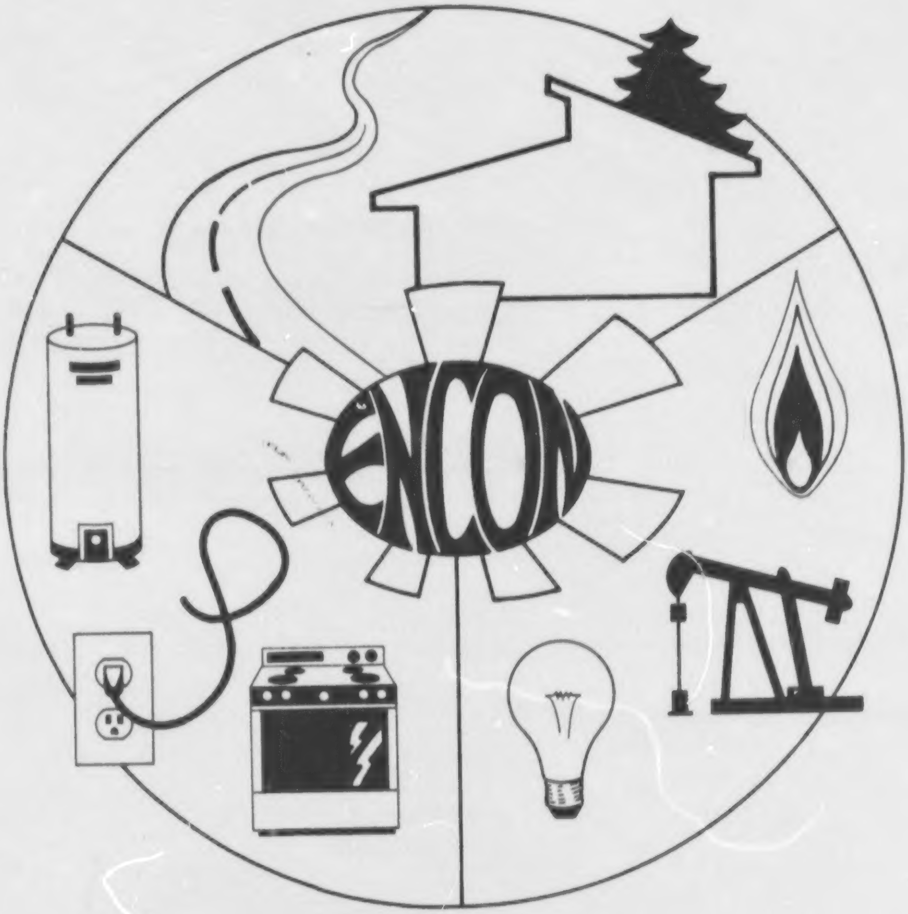
THREE TYPES OF ENERGY CRISIS

TYPE OF CRISIS	CONSEQUENCE	ACTION
ACUTE	NATIONAL BANKRUPTCY	TURN DOWN OR SWITCH OFF
CHRONIC	HIGH ENERGY COSTS REQUIRING ADJUSTMENT IN BALANCE OF USE OF BOTH NATIONAL AND INDIVIDUAL RESOURCES	DESIGN BUILDINGS TO BE THERMALLY EFFICIENT
TERMINAL	EXHAUSTION OF FOSSIL FUELS	DEVELOP ALTERNATIVE AND RECYCLABLE SOURCES OF ENERGY

SOURCE: PETER BURBERRY, BUILDING FOR ENERGY CONSERVATION, 1978.

FIGURE 1.7

ENERGY CONSERVATION
FOR VOCATIONAL STUDENTS



STUDENT MATERIALS

NAVARRO COLLEGE
CORSICANA, TEXAS

SUPPLEMENTARY ENERGY SOURCES

STUDENT MATERIAL

CONTENTS

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Tide and Ocean I-S-32

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SUPPLEMENTARY ENERGY SOURCES*

The student handout discusses several supplementary energy sources that may help America solve its future energy supply needs.

Many of the energy sources--sun power, heat from the earth, wind, ocean and tidal power--have been used by man for centuries. Water wheels, for example, date back to Ancient Persia, hot water from thermal springs was used in London during the Roman Empire period, and the windmills of Holland are familiar to everyone.

Added to this list are oil from tar sands and oil shale, synthetic oil and gas from coal, and some far-out concepts for new ways to harness some of the old and familiar energy sources.

Energy is our key to tomorrow. What might the alternative and/ or additional, energy supplies be, how will they work, and where will they come from? Let's begin by taking a look at a familiar energy source. . .

COAL

Curious. The three leading sources of energy in this country are domestically produced oil and natural gas, and foreign oil. But supplies of these fuels are dwindling, and most foreign oil sources have been unreliable.

Curious. The most abundant fossil fuel in this country is coal. But coal is also the least used of our fossil fuels.

Curious. This country's consumption of energy continues to grow. Yet, most of our coal resources remain underdeveloped.

Curious, indeed.

* Source: American Petroleum Institute

I-S-2

COAL: ENERGY IN RESERVE

Some estimates of total domestic coal resources go as high as three trillion tons. At present production rates, such amounts could last nearly 5,000 years. Not all of this supply is recoverable, however. The more meaningful estimates deal with recoverable reserves.

Given today's prices, current technology and existing environmental constraints, the amount of economically recoverable reserves is estimated to be in the 250-300 billion ton range. Such reserves could last at least 300 years. This compares with the present proved reserves of domestic oil and gas which are estimated at only about 11 times current annual production.

Put another way, coal reserves account for 90 percent of this country's total fossil energy reserves. Gas accounts for four percent and oil accounts for about three percent.

So, this country has enough coal to help meet its energy needs for centuries to come. Enough coal to be able to tell foreign countries that we don't need their oil. Enough coal to sustain economic growth, develop jobs and raise our already high standard of living. Finally, enough coal to provide us with the time to develop other more attractive nonfossil energy sources.

There is a hitch, however, and the hitch is not simple. Domestic production of coal will have to increase substantially over the next decade while new energy sources are made commercially feasible.

Some forecasters say this country must double its production of coal by 1985, while at the same time continuing to work to develop all our other energy sources. Even then, our energy needs will far exceed available domestic supplies. But the gap between domestic supply and demand must be narrowed, and increased coal production offers the country one of its best opportunities.

THE PRESENT STATE OF COAL

Estimated current annual productive capacity of the coal industry is about 700 million tons. In addition, some 535 million tons of new capacity is planned and could be in production by 1985. It is possible then that productive capacity will measure more than one billion tons by 1985.

Still, there is no guarantee that actual production will be able to match productive capacity. For instance, coal production in the United States increased by only six percent in 1975 over 1974--from 603 million tons to 640 million tons. Another 51 million tons of productive capacity had been expected to come onstream. There were just too many problems.

Some of the problems have to do with the type of mining used in the production of coal. Basically, there are two kinds: surface mining and underground or deep mining. Each method accounts for about half of the coal produced in the United States.

Surface mining is on an average three times more productive than deep mining--some of these mines actually extract 10-15 times as much coal per man-hour as deep mines. But, there are problems.

-- The Cost. Most new surface mines are located in the western part of the country. By the time the coal produced in these mines is shipped to customers in the East, transportation costs can boost the base price of the coal substantially. And even though most western coal is low in sulfur content, most of it is also low-energy sub-bituminous coal. A ton of it has only three-fourths as many British thermal units (Btu) as eastern coal.

-- Delays. Surface mining has encountered many environmental delays. In addition, the Federal government has withheld coal land from lease sales for the past five years or so. Since nearly 80 percent of all western coal is located on Federal lands, these delays have had a significant impact on production. Deep mining, which is the principal coal mining method used in the eastern part of the country, also has problems--both environmental and technological.

-- Sulfur Content. Most of the high Btu coal in the East is also high in sulfur content. The Clean Air Act of 1970 imposes rigid sulfur emission standards. Stack-gas scrubbing, a technique for reducing sulfur emissions, is costly and creates its own environmental problems.

-- Longwall Mining. This method mechanically shears a coal seam several hundred feet on a side, while the operator is protected by a thick steel canopy. It can remove more than 80 percent of the coal in a mine. However, the method requires a great deal of investment for machinery that might sit idle half of the time, since setting up a longwall operation can take weeks. Moreover, the strata overlying American coal seams do not always lend themselves to such operations.

-- Continuous Mining Machines. This mechanical borer can churn out nearly 4,000 tons of coal per shift, if it operates without interruption. But the shuttle cars used to transport coal to the surface can convey only two to three tons per minute. Thus, the machine can sit idle 80 percent of the time waiting for other operations to catch up.

Some of these problems are being resolved through the application of technologies developed by petroleum companies. For instance, Consolidation Coal, an affiliate of Continental Oil Company, devised a system using techniques developed in the petroleum industry whereby coal from the continuous miner is fed to a crusher. The crusher breaks the coal into chunks small enough to be flushed with water through a 10-inch pipe and moved to the surface. This hydraulic system can pump coal at 10 tons a minute, or as fast as the coal is cut.

Oil companies are also applying their oil drilling know-how and technology to improve safety and to reduce environmental problems associated with the production and use of coal.

The utilization of technology perfected by petroleum companies as well as the infusion of capital which oil companies can bring to the coal industry have had a favorable impact on energy production. Three of the four coal companies acquired by four different oil companies during the 1960s experienced substantial increases in production for the five-year period immediately following the date of acquisition, compared to the five years prior to the acquisition.

This pattern of growth in underground coal mines has been slowed somewhat by coal strikes, by new and more stringent health and safety standards, and by the rigid application of environmental standards. But the fact still remains that oil company involvement in coal development enhances production.

A CRITICAL PROBLEM

The most serious problem facing the coal industry is adequate capitalization. Doubling coal production by 1985 will cost from

$18-$20 billion in current dollars, according to both government and private estimates. The entire coal industry today--and there are some 700 companies in the U.S.--is capitalized at only slightly more than $4 billion. Part of the needed money will have to come from companies that are not currently affiliated with the coal industry. It's logical that some of these companies will be oil companies since they have the capital and the expertise needed to increase America's energy production.

The options are few. We can continue to import oil from unreliable foreign sources and live with the threat of another--and potentially more devastating--oil embargo. Or we can look upon coal as a significant contribution to our energy supplies; and encourage many more companies of all kinds to help develop our vast coal reserves.

Curious. That we should even have to think twice about the choice.

Curious, indeed.

GAS FROM COAL

If we're running low on our natural gas reserves, why not make gas out of coal?

FACT--Natural gas is a clean and convenient fuel.

FACT--Americans own millions of natural gas appliances--stoves, hot water heaters, home heating furnaces, even refrigerators. These represent billions of dollars in family investment. Businesses and industrial plants own still more gas-using heaters and dryers.

FACT--The United States has a million-mile natural gas distribution system. It reaches 41 million homes, three million businesses, 180,000 factories and 53,000 schools, churches, and other buildings from Boston to Seattle and Miami to Los Angeles. This system cost over $38 billion. It is efficient and safe.

FACT--Manufactured gas (coal gas) was lighting homes and city streets long before natural gas. We must know how to make it!

FACT--Our natural gas reserves in the U.S. are dropping. We're using more than we're finding. We're beginning to import gas from the Organization of Petroleum Exporting Countries (OPEC), a cartel. But our coal reserves are almost endless.

So why use coal to make a substitute for natural gas so the billions of dollars that Americans have invested in gas-using appliances and a huge gas distribution network won't be lost?

The answer is simple: cost.

Nobody knows exactly how much gas from coal would cost in the huge quantitites that would be needed to supplement or supplant natural gas. But the educated guesses in 1976 ran from $3.50 to $4 per million Btu (British thermal units, a measure of energy commonly used by engineers and scientists). That's "wholesale", comparable to natural gas at the producing field.

WHY SYNTHETIC GAS COSTS ARE HIGH

Why does gas from coal cost so much? There is a long list of reasons. Here are a few of the most important:

1. Dirty and Difficult. Coal is a dirty, difficult and obstinate substance. Besides energy, it contains sulfur, metals, earth, and a wide variety of other difficult substances lumped under the simple word, "ash". The non-energy part of coal gets in the way, fouls machinery and process equipment, and makes a gigantic and expensive disposal problem. Worse yet, coals differ. A process that works well with one kind may not with another.

2. Needs Expensive Hydrogen. Coal gasification requires addition of hydrogen from some source, possibly water, before the coal can become gas. And hydrogen is expensive.

3. Expensive Plants. All new industrial plants are expensive to build. But when the design is new and the process technology unproven and untried on the huge scale that a commercial plant must be, the costs are fantastic. The investments, when the time comes to make them, will be risky and investors will want a return commensurate with the risk.

4. Clean Air a Must. Like all new plants, the gas-from-coal plant needs extensive special equipment to prevent air pollution. This adds to the cost of building and of operation.

5. Pipeline Quality a Must. If gas from coal is to be a substitute for natural gas, it must flow through the same pipelines and be burned in the same home appliances. This means it must be the same quality as natural gas and must burn the same way or home owners would be constantly having to readjust their appliances to fit the kind of gas they were getting that day from their supplier. The heat value must be identical to standardize the quality*, a step Mother Nature didn't worry about, and additional processing must take place (called "methanation")--at extra cost.

THE FUTURE

What's to be done? Is the situation hopeless?

Not at all.

Five experimental processes for producing a pipeline quality synthetic natural gas (SNG) have been developed beyond the laboratory stage. The most promising two of the five will be installed in a "demonstration plant" of commercial size, paid for jointly by the Federal government's Department of Energy and private companies. One will cost about $200 million and will take above five years to design, build and start up.

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*"Pipeline quality" is 1,000 Btu per cubic foot.

Hopefully, many more companies will seek to tackle this complicated and costly task. They're needed, and they'll be welcome. In time, engineering and scientific skill will come out of the laboratory and into actual operation. By the mid-1980's, the technology could be proven.

Only the economics will remain in doubt. With energy costs rising month by month, the $3.46 per million Btu target of the plants--outrageously expensive today vs. even import oil--might not seem so unreasonable. Moreover, studies indicate that the capital costs of SNG plants are approximately $2.5 million for each million cubic feet per day. With 16 plants--each with a capacity of 250 million cubic feet per day--being proposed for the country by 1990, a capital investment ranging from $9-10 billion will be needed.

Meanwhile, America will have to rely on natural gas as nature made it, husband its reserves, and give encouragement to the people who know how to find more.

OIL FROM COAL

Picture this scene:

Woman in brand new $10,000 automobile drives into gasoline station. The year is 1985. She asks that her car's tank be filled.

The attendant says:

"Lady, I have to tell you something about our gasoline. It's made from coal."

What does she say? The chances are her response would be a series of questions something like these:

"Will it run my car? Will it hurt the engine? Will it cause pollution?"

The answers: It will run the car fine (or the dealer wouldn't sell it). It won't hurt the engine--the engine will never know it was made from coal. It won't add to or subtract from her car's emissions.

Well, then, why not go ahead and fill the tank?

But wait...what's the price?

There's the rub. No one can predict whether a drop of gasoline from coal will really be available to the U.S. motorist in 1985. And no one can predict the price.

But if the cost has anything to do with the ultimate price at the service station, the price will be staggering.

When she hears the price, the woman motorist might be impelled to drive her car off to another station to get good old gasoline from oil.

THE TECHNOLOGY EXISTS

How could this be? The technology to make motor fuel from coal has been around for decades. Hitler fueled tanks and the Luftwaffe with it in World War II.

What's more, the United States has a 300-year supply of coal. But its oil reserves are small, less certain.

Imported oil is so costly, so unreliable, so complicated with power politics and an obdurate cartel, the Organization of Petroleum Exporting Countries (OPEC).

So why not substitute coal for oil as the source of fuel for America's 107 million automobiles? For the 26 million trucks and buses, 29,000 locomotives, 191,000 airplanes, and many thousands of other vehicles?

Why not turn coal into liquid fuel, refine it at existing refineries, and pump it through the hundreds of thousands of miles of existing pipelines that so efficiently deliver petroleum products to the thirsty engines of our modern industrial economy?

THE COSTS ARE HIGH

The answer is simple: If Americans want this to happen badly enough, and are willing to pay the cost, it can happen.

The Union of South Africa, faced with a hostile world ready to cut off its oil supplies for political reasons, made it happen. It has a new operating plant and is building a second plant to produce fuels from its ample coal reserves. The new plant will yield about two million gallons of motor fuels plus some synthetic gas, about the quantity that would come from a single small oil field and oil refinery. The second plant, to be built by an American company, will cost more than $1 billion.

Here in the United States, one study reported that slightly more than $8 billion would be needed through 1990 to produce one million barrels per day of synthetic crude oil from coal.

The best technical and economic estimates from all the 20 coal liquefaction plants that have ever been built are that, in the United States, oil would have to sell for $20 to $25 per barrel (42 gallons) to make coal-based motor fuels competitive with OPEC oil imported into the United States.

So gasoline from coal in 1985 or 1990 is "iffy", maybe improbable. It ought to be classified as a "hedge" at best, given the present economics of energy.

WHAT'S BEING DONE?

Well, what are we doing about all this? The answer is reassuring.

The energy industry and the federal government are hip-deep in research on ways to produce liquid fuels from coal at lower costs. Not how to make liquid fuel out of coal, but how to do it at a cost low enough to help us feel a little independent of OPEC, a little better equipped to provide an economical alternative should another embargo like the one in 1973-74 be proposed by some members of OPEC.

A lot of companies of all kinds are involved in the effort. And that's good.

Thousands of scientists and engineers are working full-time crushing coal to powder, dissolving it in solvent oils, cooking it at fantastically high pressures, mixing it with hundreds of catalysts and bathing it in expensive hydrogen. Hundreds of millions of dollars--private risk capital as well as taxpayers' money--are being funneled into the effort.

What will be the total bill for this insurance policy? No one knows. But, to build enough coal liquefaction plants to replace 10 percent of current petroleum consumption in the U.S. would cost an estimated $34 billion, based on today's technological processes.

One though haunts the planners: What if, after the five to seven years of research that is now underway, after the decision is made to commit these billions, and after the plants are built (another seven to 10 years), OPEC then cuts the price of crude oil?

OIL SHALE

You can't get blood out of a stone, goes an old saying.

But you can get oil out of a rock. Petroleum geologists and other scientists in a number of oil companies are trying to do just that.

The rock is laminated marlstone--though it's more widely known as oil shale. Some marlstones contain a solid substance called "kerogen," which is actually partially formed oil. Over the ages geologic conditions never provided the heat or the pressure to convert the kerogen to natural crude oil.

Now man is trying to finish the job for nature.

It's a tough job--and an expensive one. But it's a job that must be done, and done on a huge scale--especially if this nation is ever to reduce our heavy dependence on insecure foreign oil sources. And the more companies working on the job, the better.

THE RESOURCES ARE VAST

The kerogen locked in U.S. oil shale amounts to more than the total crude oil reserves of Saudi Arabia--the largest oil-producing country in the free world. And it's nearly 20 times greater than this nation's proved reserves of crude oil.

The largest deposits in this country, by far, lie in the Green River area of Colorado, Utah, and Wyoming. Much of the oil shale will probably never be recovered from that area. The U.S. Department of the Interior estimates that the Green River formation contains 80 billion barrels of shale oil recoverable under present conditions, and that there are at least 2 trillion barrels of known shale oil resources in the Green River formation.

The U.S. now consumes about six billion barrels of oil a year. So, oil from oil shale could by itself provide the oil needs of American consumers for about 100 years, at present rates of consumption. Once produced, oil from oil shale would move much like crude oil through the existing petroleum distribution system. It would be processed into gasoline, heating oil, jet fuels and the other petroleum products, at refineries that now process crude oil.

That's the possibility.

What about the probability?

That's something else again.

Several large-size problems must be overcome before shale oil moves from the "possible" to the "probable."

TECHNICAL PROBLEMS

It's relatively easy to produce a small amount of oil from a chunk of oil shale at about 900°F. This results in the kerogen being separated from the rock--first as a vapor mist, then, when cooled, into a liquid much like crude oil. After the liquid has been treated to remove the impurities, the shale oil can then be refined into gasoline and other products.

It works in the laboratory, and even in a small experimental pilot plant. Unfortunately, converting oil shale to shale oil on a large scale is not yet a reality.

There are two general processes for removing the oil from the oil shale. One involves physically mining the oil shale and heating it above the ground. The other involves heating the oil shale _in situ_, i.e., underground. The _in situ_ process eliminates the usual mining method and consists of fracturing and fragmenting the shale underground, introducing heat into the underground deposit to release the shale oil, and then pumping out the oil.

Oil companies are emphasizing research and development in their current oil shale development activities. A variety of processes are being tested, both above ground and underground.

One oil company, for example, is developing a modified in situ process. Under this approach, a small portion of the oil shale is removed by mining--in order to create a void space or chamber deep underground. Then, the oil shale still in the ground is reduced to rubble by use of explosives. The rubble is ignited in the chamber--which serves as a retort--and the heat frees the oil from the shale rock. The oil is then pumped out of the ground.

ENVIRONMENTAL PROBLEMS

The environmental difficulties fall into three major areas:

1. What to do with the spent oil shale rock? When oil shale is heated, it expands and fragments. For every cubic yard of oil shale that's mined, 1.2 cubic yards of rock must be disposed of after the oil is recovered. Engineers and other scientists are grappling with the problem of how to dispose of the spent shale in an environmentally acceptable way.

2. Where will the water come from? In many oil shale processes, a lot of water is needed to process shale oil, and additional water to establish new vegetation on top of the spent shale. But fresh water is relatively scarce in the Green River Basin area. There's the added problem of making sure that any salt brought up with the oil shale doesn't end up combining with underground or surface waters.

3. How will the air of the region be affected? Obviously, a certain amount of dust will be created in mining and moving the shale. And other emissions will occur during the processing stage. These problems largely can be controlled. But new regulations have been proposed that would go far beyond existing Federal Clean Air Act standards. If adopted, these regulations would wipe out just about all development of oil shale, or any other kind of industrial development in most parts of the Colorado/Utah/Wyoming area.

ECONOMIC PROBLEMS

In time--and with massive amounts of money--the technical and environmental problems associated with the mining and above-ground retorting of oil shale could be overcome.

Oil companies have committed hundreds of millions of dollars to obtain leases from the federal government--monies that gave the companies just the right to develop the oil shale on the public lands leased. Since then, they've invested millions more in environmental and other studies, and in pilot plant testing.

One oil company official estimates that it will cost some $1.17 billion (in 1976 dollars) to develop a plant to produce 100,000 barrels of shale oil a day; more than $4 billion to develop a 300,000 barrels-a-day operation. Over the long term, one study indicates that more than $15 billion will be required through 1990 to achieve a shale oil capacity of 1.5 million barrels a day. (That's less than 10 percent of current crude oil demand.)

AN UNCERTAIN FUTURE

Technical, environmental and economic problems notwithstanding, many people in the oil business believe it's worthwhile to seek to develop oil shale. They know U.S. reserves of crude oil are declining and that the only alternative to development of U.S. energy resources--including oil shale--is even greater dependence on oil from the Organization of Petroleum Exporting Countries (OPEC)--some of whose members imposed the oil embargo back in 1973-74.

But they also know that the U.S. Government holds nearly all of the most valuable oil shale lands and that oil companies must be given access to these lands if they are to develop the oil shale in any significant quantity. They also recognize that proposed government laws and regulations would make it even more difficult and costly to develop most of the oil shale.

And, over and above these practical deterrents, is this uncertain question: What happens if--after the companies invest the billions of dollars to overcome the problems associates with oil shale and to construct the oil-shale processing facilities--the OPEC cartel decides to undercut these efforts by dropping the price of their oil?

That's a billion dollar gamble some oil companies are still willing to take--and the Federal government's deregulation of oil prices will help give them the incentive to go ahead.

Right now, however, the companies find themselves faced with monumental expenses to further development in oil shale development. Meanwhile, our nation's energy situation continues to grow more serious.

TAR SANDS

If you were to go backpacking through the lonely hills outside the little town of Vernal in northern Utah, you might stumble onto a two-acre tract of cleared land on which stands a strange collection of objects: Two tall oil storage tanks, three low buildings, a water-storage pond, some air compressors in carefully placed fashion on the dark sandstone plateau.

Curiosity prompts you to ask a man in jeans standing by the oil storage tank, "What's going on here?"

He replies, "We're finding oil!"

Oil? No familiar horsehead pump nodding up and down? No derricks? You look dubious.

"Yes, oil! The Department of Energy (DOE) and an oil company are working to get oil from the tar sands you're standing on. We have the first 50 barrels of oil from tar sands in these tanks here. There are 25 billion barrels more waiting in the Utah tar sands.

WHAT WILL IT COST?

Getting the first 50 barrels of oil from tar sands cost many thousands of dollars. If the cost can be brought down, this country may have found a useful alternate source of energy.

Essentially, this material is sand found in its natural state saturated with oil or tar. That tar is a hydrocarbon identical to conventional crude oil except for its thickness--that is, specific gravity.

Most of the tar sands found in Utah, which has greater deposits than those found in 21 other states, are sandstone. Canada has tremendous deposits of the sands, containing an estimated 600 billion barrels of oil, as much as the oil reserves of the whole free world.

Standard Oil of Ohio has been experimenting with surface mining in the small fraction of Utah tar sands that are shallow enough to be mined. More than 90 percent lie too deep for open pit mining, however, and processing must be an in situ (in place) method. This involves driving conventional oil wells into the tar sand deposit and injecting steam to melt the tar or creating an underground fire to melt it. The liquid is then pumped to the surface through heated pipes. U.S. Government-sponsored experiments in that method were started in 1976.

PRODUCING OIL FROM SAND

Several companies are working in various stages of research and development of tar sands. One company--Sun--has been working to wrest oil from sticky tar sands for more than 10 years, through its Canadian subsidiary, Great Canadian Oil Sands (GCOS), Ltd., near Fort McMurray, Alberta. A number of companies before Sun failed in what seemed like an easy job to recover oil from tar sands, and the skeletons of abandoned processing plants stand in mute testimony along the Athabasca River.

In Sun's first year, the boiler and power generation system broke down several times, and during the down time, process units froze in subzero temperatures. Trying to excavate solidly frozen sands in the wintertime, the 100-pound teeth on the bucket excavators ripped off. In the summers, the engineers found that the sticky sands made vehicle maintenance a nightmare, that conveyor belts ripped and process units corroded.

Initially, the plan was to invest $67.5 million in the tar sands project. In 1973, the project had an accumulated deficit of $90 million. Sun's persistence, expertise, and capital availability seem to have paid off at last. In the first nine months of 1976, the tar sands subsidiary turned in a profit of $12.6 million, after losing $6.3 million in the same period of 1975. (A small profit was turned in 1974.)

ANOTHER PROJECT UNDERWAY

Five miles from the GCOS project, the much larger Syncrude project, which carries a $2.1 billion price tag, is moving on schedule. This is a public-private corporation, bringing together units of Exxon Corporation, Gulf Oil, Cities Services Company and the governments of Canada and the Provinces of Alberta and Ontario. Upon completion, Syncrude will be producing 125,000 barrels per day of naphtha, kerosine, and gas oil.

Canada has guaranteed that the oil from Syncrude will sell at the world price, and plans that the synthetic oil from tar sands will replace the anticipated loss of production from Canadian oil reserves over the next 14 years.

According to Federal Energy Minister Alastair Gillespie, both the Syncrude and Great Canadian Oil Sands projects will be expanded for an ultimate combined production of about 350,000 barrels per day.

TAR SANDS IN THE U.S.

The Canadian guarantee of the world oil price for oil from tar sands, if followed in the United States, might encourage the development of this country's tar sands deposits. Currently, the U.S. Bureau of Mines, Sun Company, Standard Oil of Ohio, and Oil Development Company are engaged in research programs in the Utah tar sands deposits.

TIME AND MONEY AND EXPERTISE NEEDED

Years of expensive and time-consuming experiments would be needed in Utah before commercial production could begin there. Predictions have been made that the first crude petroleum in any quantity will be produced from Utah tar sands by 1985. It can be safely predicted that synthetic tar sand oil will cost more than oil today. At least the experience of the Syncrude project indicates that the costs will be higher.

It has been estimated that every barrel a day of production capacity which the Syncrude project is developing requires a $20,000 investment compared with $6,000 a barrel for North Sea oil, and $250 in the Middle East.

Developing oil from tar sands will take much expertise and capital investment, plus the encouragement of the government to any companies willing to take the risk, to pursue tar sand development. Hopefully, many more companies of all kinds will join in this complex and costly undertaking. They all will be needed because oil from sand comes neither easily nor cheaply!

GEOTHERMAL

"Old Faithful" in Yellowstone National Park has been a popular tourist attraction for many years. Every 60 minutes, on the average, it erupts--shooting steam as much as 200 feet into the air.

This most famous of all geysers is also a visual sign of one source of new power for the nation: geothermal energy.

Geothermal energy is basically the heat deep inside the earth--a vast energy reservoir. Far beneath the surface is molten rock. In some places (most notably the western states) some of the molten rock has worked itself up close to the earth's crust. If the rock comes in contact with underground water--and the water then rises to the earth's surface--it can result in hot springs or geysers, like "Old Faithful."

The challenge is to put the earth's heat to work for the benefit of the nation and American consumers of energy.

The task of locating geothermal energy sources has much in common with the search for oil and natural gas. Much of the highly scientific and sophisticated prospecting techniques developed by the petroleum industry can be applied in finding and producing at least some of the geothermal resources.

AN ENCOURAGING START

One oil company has already found a way to harness the earth's internal heat. The company--Union Oil--has drawn on its experience in natural gas reservoir engineering to discover geothermal heat at The Geysers, in northern California. Now, a decade later, The Geysers field is the largest geothermal development project in the world. The energy from this field is supplying the electrical needs of a typical city of 500,000 people.

Two smaller, non-oil companies had been trying to develop The Geysers before Union Oil contributed its technical know-how, managerial skills and capital resources to the job. For these two companies, it was a slow and painful experience. It stretched their technical and financial resources to the limit. Union Oil, in joining with them, became the field operator--conducting the exploration, drilling the wells, connecting the pipelines, producing the geothermal steam, and delivering it to the utility to generate the electricity.

Union Oil, which is relatively small in crude oil production--with only about two percent of U.S. oil production--is thus the largest producer of geothermal energy in the nation today.

There are at least 25 other companies--including a half-dozen oil firms--searching for ways to convert the vast internal heat of the earth into usable energy. These companies are exploring mainly from Alaska to Arizona, from California to Colorado.

KINDS OF GEOTHERMAL ENERGY

Steam--the dry steam produced at The Geysers field, and the wet steam found in Yellowstone National Park and in many western states--are just two forms of geothermal energy. They're sometimes grouped together under the technical term, "hydrothermal convective"--meaning that they contain relatively high temperature fluids, at shallow depths beneath the earth. Dry steam geothermal fields are, unfortunately, rare; currently, most attention is focused on locating and developing technology for wet steam deposits.

A third type of geothermal energy is called "geopressured water." It exists widely beneath the Gulf Coast states of Louisiana and Texas--both onshore and offshore. These geopressured deposits have been trapped beneath the earth by insulating clay beds. If harnessed, geopressured waters could provide not only heat energy but also hydraulic (mechanical) energy and some natural gas as well.

A fourth type is called "hot dry rock" formations ("dry" because these rocks have not come into contact with underground waters). Indications are that these deep, hot rock deposits may be the most abundant geothermal resource in this country.

The fifth type of geothermal energy is called "magma"--molten (very hot liquid or partly liquid) rock. Magma is generally located deep within the earth.

PROMISING BUT NO PANACEA

The Department of Energy estimates that known and "inferred" geothermal resources in this country may equal 45 times all the energy used in the U.S. last year. But, before even a modest fraction of that energy becomes available to generate electricity, heat homes, and provide power for energy-intensive industries, some environmental, technical and economic problems must be overcome.

-- Environmental: What to do with salt water, toxic liquid wastes, hydrogen sulfide and methane that may come to the surface when geothermal fluids are produced.

-- Technical: How to keep fittings and valves on drilling equipment from melting under the very high temperatures deep within the earth, and how to keep drill pipe from corroding and wearing out quickly when it comes in contact with the hard rock and very salty water.

-- Economic: How to bring down the costs of drilling in geothermal zones (where the costs now are about 50 percent higher than in drilling a typical onshore oil or gas well at comparable depths).

To overcome these problems and to develop geothermal energy to the point where it can provide just five percent of current national electricity capacity may require a total capital investment of some $10 billion, Union Oil estimates. Some $5.3 billion (in 1975 dollars) of that that amount would be needed to drill at least 1,000 exploratory wells and 6,000 development wells.

Despite these huge costs, a number of companies have acquired geothermal leases from the government. They include railroads, paper manufacturers, mining firms and utilities--in addition to a number of oil companies.

It will take the best efforts, skills and capital investment of all kinds of companies and industries to tap the huge (but difficult to get at) resources of energy beneath the earth's surface. As a nation, we should be going full steam ahead to encourage everyone with the capability and competence to participate in developing geothermal energy to help meet tomorrow's energy needs.

NUCLEAR

> WANTED: New energy source for growing country. Must be safe, low cost, compatible with need to protect environment, readily available. Every reply given courteous response. Send proposals to Box U.S.A.

Sounds ridiculous? But not because it's a "want ad" for an energy source.

This "safe, cheap" energy source has been in commercial use for more than 15 years: nuclear energy. But since Three Mile Island, people have questioned how safe it is.

Today, there are 64 power reactors operating in this country, with 162 others currently being built or in the planning stage. But many projects have been delayed, and nuclear power simply isn't moving ahead as rapidly as envisioned back in the 1950's.

Ten years from now, the electricity generated from nuclear power could amount to the equivalent of five million barrels of oil every day--almost as much oil as we're currently importing. So, if the U.S. is to become less dependent upon high cost, insecure foreign oil, nuclear power--and all other available and economical sources--must be developed rapidly.

WHAT IS NUCLEAR ENERGY, ANYWAY?

Nuclear energy is used to generate electricity. In the process, nuclear fuel--primarily uranium--is used instead of conventional coal, oil or natural gas. The fuel atoms split apart in the reactor, and this process releases enormous quantities of heat. The heat makes steam, and the steam drives a turbine to make electricity.

If more nuclear plants could be planned and completed, and if sufficient supplies of uranium fuel could be produced, oil and clean-burning natural gas could be used for purposes other than generating electricity.

OKAY. BUT WHY DO WE NEED IT?

Just about everyone knows what happens when electric power fails: heating systems shut off, food spoils, cooling systems fail, factories grind to a halt. We Americans are counting more and more on electricity for power. Between now and 1985, according to government estimates, electricity demand will increase by more than five percent each year--much faster than all energy sources.

Nuclear power is (with the exception of coal) the only major energy source now available to meet those needs. Use of more oil would mean stepping up imports. Natural gas can't be used because gas reserves are declining. Water power? There aren't enough sites for new dams. Geothermal power and exotic forms of energy, experts say, won't be available in any substantial degree for decades.

Use of nuclear power for electricity is also attractive because of the relative low cost of the fuel. A recent study by the Department of Energy showed that nuclear fuel costs could nearly triple before becoming as expensive as using oil to generate electricity.

I GUESS MY MAIN WORRY IS ABOUT SAFETY.

You have a lot of company. In recent years, concern about the safety of nuclear power plants has grown, even though the plants have compiled a remarkable safety record. Opponents of nuclear energy are demanding a complete halt to new nuclear plant construction and a phasing out of units already in operation because nuclear could be dangerous under some unlikely circumstances.

In answer, government scientists have repeatedly stressed the low risks. They point to the fact that nuclear reactors are designed, built and operated so as to be inherently safe; that independent "backup" systems assure that--in the event of an incident--a reactor would be shut down with no adverse effect. In addition, all aspects of nuclear plant licensing, construction, operation and maintenance are regulated by the Nuclear Regulatory Commission. The safety measures have prevented damage or injury to the public in more than 15 years of commerical operations. But the "might be" still haunts further development of nuclear energy.

WHAT ABOUT HARM TO THE ENVIRONMENT?

Nuclear power is recognized as a clean source of energy. Chemical pollutants are not released into the atmosphere. Plants are designed to contain practically all radioactive material in a closed system.

The chief concern from an environmental standpoint today is "thermal pollution." Nuclear plants use large amounts of cooling water, and return it to its source several degrees warmer. That's caused problems in the past. Today, if studies show that the warmer water is harmful to aquatic life, cooling towers can be built to release the heat into the atmosphere, thereby eliminating the problem.

Disposal of waste is a serious and understandable concern. Still, most of the wastes are not highly radioactive. They're disposed of in commercial burial grounds. The small amount of waste that is highly radioactive is disposed of by technology developed through our military weapons program and involves no harm to the public or to the environment.

WHAT ABOUT THE URANIUM ITSELF? WILL WE HAVE ENOUGH?

Uranium is commonly found in sedimentary rocks, and according to the National Petroleum Council, about 95 percent of U.S. uranium reserves are located in the western U.S. Will we have enough? To meet our needs entirely from domestic resources, energy companies must find an average of 65 million pounds every year from now until 1990.

Before it can be used to make electricity, uranium must go through several processing steps. After being mined, uranium ore is "milled"--crushed, subjected to a chemical process and finally "enriched" to increase its relative fissionable material content. This latter step is carried out by the U.S. government.

Thre are also costs involved in the nuclear fuel cycle which includes mining, milling, conversion, enrichment, fabrication, transportation, reprocessing and waste storage. Studies indicate that between $13-$22 billion will be needed through 1990 for the five cycles alone. Much more additional capital will be needed for the constructing of nuclear generating plants as well as for transmission and distribution facilities for the electric power produced. Estimates in this category range from $169-$379 billion.

Because it takes up to 10 years to develop a uranium mine and the associate milling facilities, an extensive effort to meet uranium needs must be undertaken as soon as possible, if the potential contribution of nuclear power is to be fulfilled. At present, about 185 different companies are exploring for uranium. Only about 50 of them are oil companies of all sizes, investing capital and applying their expertise and technology to finding new supplies of uranium.

Many more companies of all kinds will need to join this effort to help provide domestic fuel for reactors through the 1980s.

SOLAR

In an otherwise nostalgic decade, solar energy has eclipsed apple pie and is giving Mom a close race for the title of most popular platitude of the "Seventies."

EVERYMAN'S SOLUTION TO THE ENERGY PROBLEM

The sun is free. It shines everywhere. It pollutes nothing. It blesses everything. And the popular writers are more insistent than ever that practical solar energy finally is here.

Is it?

When?

Is this the real answer to high cost energy?

To dependence on the Organization of Petroleum Exporting Countries (OPEC) oil cartel?

Like most simple questions, these have complex answers.

WHAT IS IT?

The sun is the source of almost all of the energy used on the earth. The sun's powerful rays trapped in plant and animal matter can be tapped in fossil fuels such as oil, natural gas and coal.

Or the energy from the sun can be used more directly to provide heat or generate electricity. Solar heating uses very basic technology--as simple as water warmed by flowing over a sun-heated roof being used to heat a house. At today's prices, however, a solar system averages between $4,000 and $8,000.

I-S-30

Approximately 70 American companies are involved in the manufacture of solar panels for use in heating homes and other buildings. In time, more companies can be expected to enter this field--and that's all to the good.

Solar electricity generally involves one of two methods--either easily accomplished with current technology.

One involves catching the sun's rays on reflectors and concentrating them in a smaller area, much as a magnifying glass does. This more intense heat is then used to produce steam from water, which in turn operates a turbine to produce electric power. A power plant using this method of converting sunshine to electricity was put into operation in Egypt in 1913.

The other method requires the sun's rays to pass through a photovoltaic cell, made of a substance such as silicon, that converts sunshine directly into electricity. Solar cells were first used to produce electricity in 1954 by an American research corporation.

WHAT'S THE CATCH?

This country is running out of inexpensive oil and gas, and we're having to buy more and more from the Arabs and other members of the OPEC cartel at constantly increasing prices. But sunshine is free and plentiful. If solar energy is technologically sound--and not just a trendy gimmick--why aren't we using it on a large scale?

Solar energy has several problems. Like nighttime. And winter.

Storage of solar energy--in batteries, for example--is very expensive. Virtually all solar energy systems now in operation require conventional systems side-by-side on an auxiliary basis.

Besides the weather and the seasons, geography plays a large part in the practicality of solar energy. It works best in the parts of the country with the most exposure to the sun--in the South and the West. In such areas, solar energy may be far more valuable for air conditioning than as a source of heat.

Even in the sunny Southwest, it has been estimated that a power plant using reflector panels to concentrate the sun's energy to produce steam would require 10 square miles of land to produce enough electricity for a city of one million people. Environmental problems aside, construction of such a facility would cost several times that of a conventional power plant.

The cost of direct conversion of sunshine to electricity through solar cells is also high. A solar cell capable of producing one watt of electricity currently sells for about $15.50. That cost must be about 50 cents if it's to compete with conventional energy.

These problems must be overcome if we are to utilize the energy of the sun to meet our future needs. Accordingly, the U.S. government spent $160 million on solar research in 1976 and perhaps nearly twice that amount in 1977.

IS SOLAR ENERGY WORTH PURSUING?

Very definitely. The costs are high, but they are coming down. And the costs of conventional energy are continuing to rise. It costs a lot to drill offshore or transport oil from the North Slope of Alaska--which are the places we have to look for petroleum now.

The high costs of converting solar energy to a usable form can be reduced. American companies have to bring those costs down in order to mass produce a product and make a product. And the United States is the world's leader in companies with people who know how to produce energy.

Today, at least five major oil companies are involved in solar energy. Three companies--Exxon, Shell, and Mobil--have affiliates that either research or produce solar cells. Gulf, through the General Atomic Company, a joint venture with the Royal Dutch/Shell Group, is using a different techniques to produce solar energy. And, appropriately enough, the Sun Company is also involved in solar research.

Much of this costly research is devoted to the reduction in costs of solar cells, although some of the affiliated companies are already marketing solar equipment.

America's energy companies have the expertise and the capital. Petroleum companies and other companies in many related fields can do the research necessary to solve the technological and economic problems present in solar energy.

DOE estimates that it will probably be well beyond the year 2000 before solar energy makes a significant contribution to U.S. energy needs. In the meantime, the companies with experience in energy want to participate (along with other kinds of companies) in the effort to make solar energy a practical reality.

Energy development is what oil companies know how to do best.

After all, oil is nothing more than solar energy trapped in the ground for a few million years.

TIDE AND OCEAN

Think back. Remember when, as a small child at the beach, you were knocked head over heels by a big wave? Or that first time you jumped off the end of the pier into deep water and noticed how much colder it got the deeper you went in the water?

You didn't know it then, but you were experiencing firsthand some of the energy potentials of the oceans and waters of the earth. Today, scientists are trying to harness that energy for the future use of man...the energy of the waves and tides, ocean winds and currents, and temperature variations.

ENERGY POSSIBILITIES IN THE SEAS

They've found at least eight different energy possibilities in the seas around us. Some are more promising than others. All require lots of money to develop and construct. But they have this in common --They are self-renewing--and with some more research could be environmentally acceptable, a big plus in this age of fast-disappearing mineral resources.

-- Ocean Thermal Energy: There's a great difference in temperature between the sun-heated surface waters and the colder waters below the surface. This temperature difference could be tapped to turn turbines and generate electricity.

-- Kelp Bioconversion: Sunlight and ocean water can be used to grow kelp which, in turn, could "capture" the sun's energy. Scientists hope by processing the seaweed to produce fuels, livestock feeds, chemicals and fertilizers.

-- Ocean Waves: The movements of the waves can be mechanically converted into turbine power. The power could then be used to generate electricity.

-- Tides and Tidal Currents: The flow of the tides in and out of restricted areas can be harnessed to turn electric turbines.

-- Ocean Currents: Just as the tides can be used to power turbines, ocean currents can be used to turn the blades of underwater turbines.

-- Ocean Wind: Both floating and stationary "windmills" have been offered as possible sources for harnessing the ocean winds in near-shore areas, where winds are sufficiently strong and constant.

-- Salinity Gradient Power Systems: This involves using the energy released when fresh water from rivers enters the salty waters of the ocean.

-- Ocean Geothermal Power: Man has developed the means to use some of the near-surface heat of the earth to turn turbines at The Geysers, California. In much the same way, near-surface heat under the oceans could also be used to develop electricity.

HARNESSING THE TIDES

Only one of these potential ocean energy sources--tidal power--has been used to date on a commercial scale. Two major tidal power projects are in operation today--one in the Rance River, where it flows into the English Channel on the French side; the other off the Ura River, where its waters meet the arctic waters of the Barents Sea near Murmansk, Russia.

Both of these facilities are pumped storage plants. That is, the turbines are designed to generate electricity as the tides move in and out. During periods of low demand, the turbines can pump water into a storage reeservoir, supplementing the volume of tidal water available when the reservoir is emptying.

The Rance tidal works includes a 2,460-foot-long dam across the river's estuary, a power plant capable of generating 500,000 kilowatts (kw) of electricity, and a reservoir to hold more than six billion cubic feet of water. The 24 generators now in operation are capable of meeting the elecrical power needs of a city with 250,000 people. The investment cost for dependable peak power at the site ranges between $25-40 per kw compared to about $9 per kw for oil, gas or nuclear power. The accumulated total cost of this project to date has been nearly $100 million.

We have no tidal power plants in the U.S., although experiments were conducted and plans made to harness the tides entering and leaving the Bay of Fundy near Passamaquoddy, Maine. The tides there rise to 40 or more feet. The project, started in the 1930s, was abandoned before construction began because of its high cost and the ready availability of other energy sources.

As our oil and natural gas resources have diminished, and environmental concerns have delayed or prevented a number of coal mining and nuclear power projects, interest in tidal power has been revived. Someday, we may be getting power from Passamaquoddy and other U.S. tidal projects.

OCEAN THERMAL POWER

Ocean thermal conversion (OTEC) has caught the eye of officials in Washington, D.C., as a promising source of supplemental energy... energy that could be tapped to help ease the pressure on our declining petroleum reserves. Congress authorized $19 million for OTEC development during Fiscal Year 1976-77, compared with just $1 million two years earlier.

Several types of "ocean-going" power plants are visualized. In each case, the system would basically work like this: Warm water would be drawn into the system, wehre it would heat tubes containing a liquid that has a low boiling point. The liquid would vaporize. The vapor, in turn, would drive a turbine generator. Then cold water from lower depths would be pumped up to cool the vapor, condensing it into a liquid, and the process would repeat itself. The electricity could be carried to shore through underwater cables.

The procedure requires areas where the water temperature at the near-surface differs from deep-water temperatures by 30 to 40 degrees Fahrenheit. Probable sites near the U.S. include the Gulf Stream off Florida and the U.S. Virgin Islands.

So, the basic technology exists. However, there are some major problems to be overcome. For example, the present cost of some of the equipment is very high, while the efficiencies are low. And there's a problem in stopping microorganisms from gathering on the equipment, as well as in it, thus reducing its efficiency. But, if a way is found to solve the technical and cost problems, a significant step could be achieved in finding a self-renewing, non-polluting electrical power source for the future.

It will be a number of years before any of the proposed tidal and ocean energy systems become practical--from either an economic or technical standpoint. But it's important for all Americans that every reasonable means of developing energy be pursued, and that every company with the interest, technical know-how and financial capability be encouraged to seek tomorrow's answers to today's energy problems.

Perhaps, by combining a number of different and new energy sources, our energy future can be shaped into a self-sufficiency that will allow us to provide for our needs, and to do it in a more environmentally acceptable manner.

WIND

Wind. A devastating power. Feared through the ages for its awesome destruction. A subject of romantic song and myth. Indian lore. Spirits. Maria! And a practical energy source.

No, the practical side is not out of character. In fact, wind is one of man's oldest energy sources. At least 5,000 years ago, the Egyptians used sails on their Nile River craft. The Persians, in 200 B.C., used wind turbines to grind their grain. Through the centuries, others have used the wind for similar tasks.

In the past 100 years, millions of small windmills have been used in the U.S. to pump water and generate electricity. You can still see some in operation on farms and ranches throughout the middle and western states.

A number of larger windmills have been built--mostly in Europe--for experimental generation of electricity. The world's largest, however, was the 1,250-kilowatt Smith-Putnam machine built near Rutland, Vermont, in 1941. For more than three years, this 175-foot-diameter propeller-type machine fed electricity into the commercial network. But, in the era of cheap oil and natural gas, wind power was not attractive enough to be more heavily developed.

Today, though, with our higher energy costs and declining resources of oil and natural gas, there is renewed interest in wind power. It is one of many alternate energy sources that could help fill our needs in the future. A lot of people, individually and in businesses, are seeking to harness the winds, in one way or another. That's a good sign.

KINDS OF WIND MACHINES

Researchers are experimenting with many types of wind machines. Some are like farm windmills. Some look like multibladed bicycle wheels. Other contain propellers or paddles. Still others are vertical-axis turbine or airfoil machines that look like eggbeaters. Another type is the cupped anemometer you have probably seen measuring wind speed.

In addition, there are various combinations and other, more sophisticated engineering designs.

The mechanical energy of these machines can be used directly to pump fluids to do other work, or it can be converted to electricity, heat or fuel.

The concept of wind power is an appealing one. It's inherently simple, it's inexhaustible, and it's nonpolluting.

But wind power isn't without its problems. Being an indirect form of solar energy, wind has some of the same disadvantages. The average wind strength varies among different areas of the country. In all areas, it's intermittent. And the equipment to harness it is expensive. Wind machines already in commercial production cost about four times as much as ordinary generators.

So, researchers are trying to: (1) improve the technology and reduce the cost, and (2) develop economical ways to store or "even out" the energy produced by the wind machines.

If the energy is converted to electricity, it can be stored in batteries. But significant improvements in battery storage capacity and cost are needed. Electricity from a wind machine can also be used to produce hydrogen from water by electrolysis. The hydrogen can be compressed, stored, and used for fuel as needed.

Wind machine energy can, through friction, be converted to heat. The heat can be stored as hot water or in other substances.

The machine can also be used to pump water to a higher level for storage. The water can be released as needed through turbine generators to produce electricity.

Finally, the wind machine could be connected into a conventional energy system to reduce storage requirements and still provide consumers a continuous energy supply.

The Department of Energy (DOE) is operting a 100-kilowatt experimental wind turbine generator near Sandusky, Ohio. This propeller-type machine could provide power for 30 homes. The cost of constructing this generator was nearly $1 million or approximately $32,600 per home. The purpose of this experiment is to provide data for larger machines DOE will build over the next three years. These machines could be the largest ever built--big enough for more than 400 homes.

WIND POWER FOR THE FUTURE

What is the future of this appealing concept of wind energy? On a nationwide basis the total contribution will likely be quite small. To produce 20 percent of today's power needs or five percent of requirements in the year 2000, we would need hundreds of thousands of the largest wind turbines presently conceived, according to DOE. The land requirements and aesthetics of these several-hundred-foot towers could be unacceptable to many people.

The best promise may lie in use by smaller utilities, industries and homes, where wind power could well make a significant contribution.

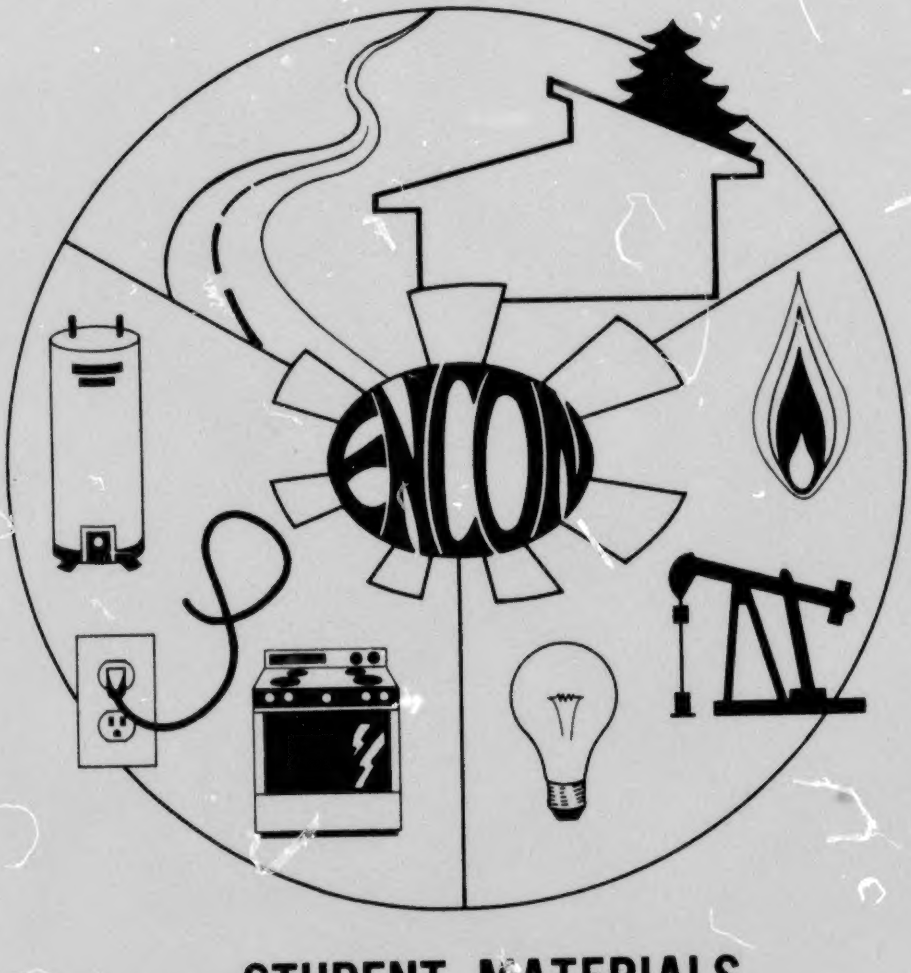
THREE TYPES OF ENERGY CRISIS

TYPE OF CRISIS	CONSEQUENCE	ACTION
ACUTE	NATIONAL BANKRUPTCY	TURN DOWN OR SWITCH OFF
CHRONIC	HIGH ENERGY COSTS REQUIRING ADJUSTMENT IN BALANCE OF USE OF BOTH NATIONAL AND INDIVIDUAL RESOURCES	DESIGN BUILDINGS TO BE THERMALLY EFFICIENT
TERMINAL	EXHAUSTION OF FOSSIL FUELS	DEVELOP ALTERNATIVE AND RECYCLABLE SOURCES OF ENERGY

SOURCE: PETER BURBERRY, BUILDING FOR ENERGY CONSERVATION, 1978.

FIGURE 1.7

ENERGY CONSERVATION
FOR VOCATIONAL STUDENTS



STUDENT MATERIALS

NAVARRO COLLEGE
CORSICANA, TEXAS

MODULE II

SURVEYING ENERGY USAGE

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. It is intended for use independently, integrated with the other 10 modules into a program on energy conservation, or integrated into conventional courses as a unit of instruction on Surveying Energy Usage.

MODULE II

SURVEYING ENERGY USAGE

MODULE DESCRIPTION:

This module presents an overview of energy usage in the United States in each of four broad categories: residential and commercial, industrial, agricultural, and transportation. The importance of energy to each of these areas, and their substantial reliance on energy for survival, makes the student aware of the need for energy conservation. Problems related to conservation measures and proposed solutions are examined for practicality and adaptability.

GOAL STATEMENT:

The objective of this module is to train secondary and postsecondary students to recognize energy needs and energy consumption patterns in several areas of use. Further, the module prompts a search for conservation measures in each use area--residential/commercial, industrial, agricultural, and transportation.

READING GRADE LEVELS:		SUGGESTED TEACHING TIMES:	
Lecture	16	Secondary	2 hours
Lab	17	Postsecondary	2 hours

MODULE II

SURVEYING ENERGY USAGE

UNITS:

- I. Residential/Commercial Energy Use and Conservation
  - A. Household Needs
  - B. Methods of Conservation
  - C. Commercial Energy Use
- II. Industrial Energy-Use and Conservation
  - A. Industrial Energy-Conservation
  - B. Energy Management
  - C. Waste Heat Recovery
  - D. Recycling
- III. Agricultural Energy-Use and Conservation
- IV. Transportation: Energy Use and Conservation
  - A. The Automobile
  - B. Problems in Transportation
    - (1) Regulations vs. Economy
    - (2) Inter-city Travel
    - (3) Commuter Problems
  - C. Proposed Solutions
    - (1) Conservation, Regulations, Driving Habits and Engine Changes
    - (2) Alternatives to Fossil Fuels
      - (a) Electricity
      - (b) Other Combustion Fuels

MODULE II

SURVEYING ENERGY USAGE

TERMINOLOGY

Air washer--a water spray system or device for cleaning, humidifying, or dehumidifying the air.

Appliance--an instrument or device designed for a particular use; a household or office device (as a stove, fan, or refrigerator) operated by gas or electric power.

British thermal unit (Btu)--a unit of heat energy equal to the heat needed to raise the temperature of one pound of air-free water from 60° to 61° F at a constant pressure of one standard atmosphere.

Calorie--a unit of heat energy equal to the heat required to raise the temperature of one gram of water from 14.5° to 15.5° C at a constant pressure of one standard atmosphere.

Energy--the capacity for doing work.

Hydrogen gas--the first chemical element, symbol H in the periodic table, atomic number 1; under ordinary conditions, it is a colorless, odorless, tasteless gas composed of diatomic molecules, H.

Hydroponic gardening--raising plants in a liquid of nutrients instead of soil.

Insulation--material that does not readily conduct heat energy.

Megawatt--a unit of power, equal to 1,000,000 watts. (abbreviated MW.)

Methane--a combustible substance produced by converting waste products and animal feces into gas.

Phosphor--a substance that emits light when excited by radiation.

Pyrolysis--chemical change brought about by the action of heat.

Quad--a unit of heat energy equal to 10 British thermal units.

R-value--the resistance of a material or an entire wall to the flow of heat. Insulation is rated in R values to show its resistance to heat flow. The higher the R-value, the more resistant the material is to heat.

Ton-mile--amount of energy it takes to move one ton of payload one mile.

Vacuum gauge--a gauge indicating the degree of negative pressure.

MODULE II

SURVEYING ENERGY USAGE

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MODULE II

SURVEYING ENERGY USAGE

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. Most of the energy used in our households is used for:

   a. heating water
   b. cooking
   c. cleaning
   d. cooling and heating our households

2. Eighty percent of the electricity produced in the United States is produced by:

   a. hydroelectric generators
   b. fossil-fueled generators
   c. hydrogen generators
   d. solar means

3. About 40 million single-family homes in the United States are inadequately protected from outside weather.

   a. true b. false

4. Current Federal Housing Administration regulations call for at least an R-19 value of insulation in attic floors or over top floor ceilings in new houses.

   a. true b. false

5. _______ single-family homes have no attic or ceiling or top floor insulation.

   a. 1 million
   b. 5 million
   c. 10 million
   d. 15 million

6. For every degree the average temperature above 70°F is reduced in a home, savings of from _______ to _______ percent are normal.

   a. .01, .05
   b. 5, 10
   c. 2, 3
   d. 1, 1.5

7. A six percent reduction in energy consumption can be accomplished by reducing the hot water temperature by _______ degrees F.

   a. 1
   b. 5
   c. 10
   d. 20

8. Most hot water tanks are set for 140°F water.

   a. true b. false

9. Unless a dishwasher is used, a hot water temperature of _____ °F is usually adequate:

   a. 200
   b. 100
   c. 300
   d. 120

10. It is important to keep fireplace dampers closed when the fireplace is not being used.

    a. true b. false

11. Industrial consumption of energy now amounts to about _______ to _______ percent of the nation's total energy budget:

    a. 5, 10
    b. 20, 25
    c. 35, 40
    d. 60, 75

12. In industry, 27 percent of the nation's energy is used in direct heating and the production of heat.

    a. true b. false

13. About _______ percent of all the energy used by industry is provided by natural gas:

    a. 10
    b. 15
    c. 35
    d. 50

14. Industry consumes about _______ percent of all the coal used in the United States.

    a. 10
    b. 15
    c. 35
    d. 55

15. The major use of petroleum by industry is in the production of _______:

    a. steel
    b. metals other than steel
    c. chemicals
    d. textiles (natural)

16. 60 to 75 percent of the aluminum used in this country could be recycled.

    a. true b. false

17. The recycling of paper can save energy.

    a. true b. false

18. The total amount of energy used directly in agriculture is of great significance in our total energy budget.

    a. true b. false

19. About _______ percent of the nation's energy budget is consumed by the private automobile:

    a. 5
    b. 10
    c. 15
    d. 50

20. The standard car engine will produce 3-5 more miles per gallon at 50 m.p.h. than it will at 70 m.p.h.

    a. true b. false

MODULE II

SURVEYING ENERGY USAGE

ANSWERS TO PRETEST

1. d. cooling and heating our households
2. b. fossil-fueled generators
3. a. true
4. a. true
5. d. 15 million
6. c. 2, 3
7. c. 10
8. a. true
9. d. 120
10. a. true
11. c. 35, 40
12. a. true
13. d. 50
14. c. 35
15. a. steel
16. a. true
17. a. true
18. b. false
19. c. 15
20. a. true

MODULE II

SURVEYING ENERGY USAGE

UNIT I

RESIDENTIAL/COMMERCIAL ENERGY USE AND CONSERVATION

UNIT OBJECTIVES

1. Understand energy needs and uses in the U.S. household.
2. Discuss methods of energy conservation available to the homeowner, including insulation, weatherstripping, and general maintenance tips.
3. Recognize energy uses peculiar to the U.S. commercial sector and discuss conservation methods to improve energy consumption efficiency.

MODULE II

SURVEYING ENERGY USAGE

UNIT I

RESIDENTIAL/COMMERCIAL ENERGY USE AND CONSERVATION

LECTURE

A. HOUSEHOLD NEEDS

Almost 20 percent of the energy used in the United States is used in 70 million households. By far, the greatest amount of energy is used in heating and cooling our homes. Seventy-one percent of residential energy is used in space heating and cooling, 16 percent is used for heating water, and the remaining 13 percent goes into lighting and running various small appliances. Ninety-eight percent of the space and water heating is done through the burning of oil and natural gas. Most of the remaining 2 percent of space and water heating is supplied by coal. Electricity accounts for an insignificant amount in this area. Electricity is the only significant energy source for cooling, lighting, and running small appliances in the residential sector. It should be noted, however, that about 80 percent of the electricity produced in this country is produced by fossil-fueled generators. Thus, residential energy almost totally depends on fossil fuels. When we consider that residential use accounts for about 20 percent of the total energy used in this country, it becomes clear that this must be an area of concern. While schools, stores, hospitals, offices, and all other commercial (non-industrial) enterprises are also using energy in most of the same ways as residences, the energy use by this group of non-residential consumers amounts to only about 11 percent of the total

ACTIVITIES

This unit is devoted to a discussion of energy use and conservation in the residential and commercial sectors. During this study, samples of several different types of insulation materials should be available for the students to observe and handle: fiberglass batts of different thicknesses, loose-fill material, rock wool (if available), cellulose, and/or foamed-in-place material (similar material is available in pressurized cans for demonstration purposes).

During this unit there might also be an ongoing demonstration experiment showing the actual value of insulating materials. Many different demonstrations might be devised. A simple but effective one would be to take two identical containers (glass jars, for instance) filled with equal amounts of hot water.

One jar should be completely enclosed in insulating material (or several identical jars could be covered with different types of different amounts of insulating material) and one jar should be uninsulated. Temperatures of the water taken at the beginning, middle, and end of the session should show a much smaller drop of temperature of the insulated jar(s). If an artificial wind can be created (a small electric fan would do this job), the results will be even more dramatic.

energy consumed. Commercial consumers are generally more cost conscious (and, therefore, energy conscious) than residential consumers and also usually start from a base of more energy efficient contribution.

As energy costs have escalated, commercial consumers have been more willing to introduce lower heating and higher cooling temperatures and reduced lighting levels than has the average residential consumer. There are more reasons than cost that have brought this about. The commercial user of energy is more exposed to social pressures to reduce energy use than the residential consumer. The "I'm a good person" syndrome works for the commercial consumer who proves daily to the customers that the firm is conserving energy. Who is to know when the residential consumer is doing his/her part? How much goodwill does a homeowner generate with a cooler house in winter and a warmer one in summer? A large commercial building ablaze with lights long after working hours clearly states that the owner is not concerned about the energy crisis and the owner quickly hears about it from consumers or clients. Who speaks to the homeowner whose house is ablaze with lights behind drawn shades?

B. METHODS OF RESIDENTIAL CONSERVATION

Clearly, we must make the residential consumer aware that his/her 20 percent share of the energy use in this country is significant. One must realize that any contribution made through reduced comsumption in any way can make a significant impact on the nation's total energy use especially when multiplied by over 200 million residents.

C. INSULATION

About 40 million single-family homes in the United States are inadequately protected from outside weather. In many cases, an investment in insulation would reduce the energy demand of heating and cooling equipment from between 10 percent up to 30 percent. In most cases, the price would be about the same as the price of a color television console. But the price will be recovered several times over the years through lower utility costs.

Current Federal Housing Administration regulations call for at least an R-19 value of insulation in attic floors or over top floor ceilings in new houses. This is a good general guide for older houses; however, in areas where temperatures are extremely low or high, higher R-values of insulation are desirable. (R-values are insulation efficiency ratings, with higher R-values representing more effective insulating capabilities. Each different material varies in R-value according to thickness. While 6 to 6 1/2 inches of fiberglass batts or blankets have an R-19 rating, it takes 8 to 9 inches of loose fill fiberglass to have the same rating.)

At least 15 million single-family homes have no attic or ceiling or top floor insulation. If insulation were added, there would be a savings of 8 percent of the total residential heating energy used each winter day. This not only amounts to equivalent of millions of gallons of oil each year, but also many dollars in savings to the residential consumer.

Another easily accomplished conservation method for the residential consumer is caulking and/or weather stripping doors and windows. Windows and doors can be tested for air-tightness by moving a lighted candle around the frames and sash edges. A flickering flame is a clear indication of the need for attention to these areas. Will a quarter slide under a closed outside door? If so, weather stripping is called for. Properly installed combination storm windows are obviously desirable, but clear plastic film taped to the inside of window frames will also provide considerable savings. (However, it should be noted that using plastic increases the fire hazard.) Savings of up to 10 percent per year in space-heating costs can be realized through various use of these measures.

Space-heating costs and energy consumption can also be reduced by lowered living temperatures. For every degree the average temperature above 70° is reduced in a home, savings of from two to three percent are normal. Where temperatures are only reduced at night, the savings are about one percent for each degree of reduction. For most people with space-heating costs in the $250-$700 per annum range, these savings may not seem sufficiently significant to bother with. The emphasis must be made, however, that the savings are not just in dollars but in gallons of oil or cubic feet of gas, and when multiplied by 70 million households represents significant savings of irreplaceable resources.

1. A reduction of 10 degrees in hot water temperature can reduce energy use here by 6 percent and reduce the temperature setting of the water heater, by 10 degrees, for a 6 percent reduction in energy use, and by 20 degrees may save 18 percent or more. Most hot water tanks are set for 140° water, but water at 120° is adequate for most families unless a dishwasher is used.

2. Use cold water, not hot, for household cleaning where possible.

3. Use a cold water setting for washing and/or rinsing clothes.

4. Use ventilating fans in bathroom and kitchen as little as possible. Most will exhaust a houseful of warmed or cooled air in an hour.

5. Reduce dishwasher use. One less use per week for each dishwasher in the country could save 9,000 barrels of oil daily.

6. Keep fireplace dampers closed when the fireplace is not being used. They vent the heated room air directly to the outside.

7. Close off unoccupied rooms and shut their heating or air conditioning vents.

8. Turn off lights when not needed, and use low watt bulbs for porch lights, closets, television rooms and other areas where bright lights are not required.

COMMERCIAL ENERGY USE CONSUMPTION:

In the commercial sector, businesses have made many efforts to conserve energy. Many businesses change their hours of operation to take advantage of daylight savings time. Some businesses close at 5 p.m. on week days and stay open Sunday to conserve the extra electricity required to operate until 9 or 9:30 p.m. each evening. Many businesses put an automatic regulator on the thermostat to keep the temperatures for heating and cooling at the minimum setting for maintaining comfort and conserving fuel. In many areas of the country, reflective film is applied to plate glass windows to reduce sunlight penetration and thus save on the cost of cooling buildings. Lights in parking lots are run by automatic timers and are turned off as soon as

Texas has "Blue Laws" which require commercial businesses to close on either Saturday or Sunday or restrict the selling of certain items on these days if they are open seven days a week. Could there be an argument for repealing Texas "Blue Laws" as an energy conservation measure?

the stores close at night. Signs advertising businesses are seldom left on all night as they once were in many large cities. In some areas, every other street light is left dark in order to save energy.

City planners take the energy conservation problem into consideration. New buildings are designed and constructed to conserve energy. Installing a minimum of windows and better insulation and duct work for air conditioning and heating are measures that have been taken as a result of careful planning. Double lobby doors have been installed in many large buildings to eliminate drafts and keep heat (or cool air) inside the buildings when people enter or leave. Conservation measures taken to date have been extensive, but there are still many areas of public domain where more effort could be expended. Lights should be turned off in public restrooms and lounge areas when no one is using the facilities. Office lights could be turned off during lunch hours. Many small measures could add up to a large savings in energy.

The class could discuss at this point the areas they are familiar with at the college, city, and county level, and decide if there are measures that should be taken that could result in saving energy. They might even become enthusiastic enough to undertake a project to educate their fellow classmates in this area. (A simple sign on each light switch, such as "When not in use, save the juice! - Please turn light off when leaving the room" might start their families on an energy-saving binge!)

MODULE II

SURVEYING ENERGY USAGE

UNIT II

INDUSTRIAL ENERGY--USE AND CONSERVATION

UNIT OBJECTIVES

1. Recognize the use and consumption of energy in the industrial sector of the U.S.
2. Discuss the sources of industrial energy supply.
3. Discuss conservation measures available to industry through energy management.
4. Discuss conservation measures available to industry through waste heat recovery.
5. Discuss conservation measures available to industry through recycling.

MODULE II

SURVEYING ENERGY USAGE

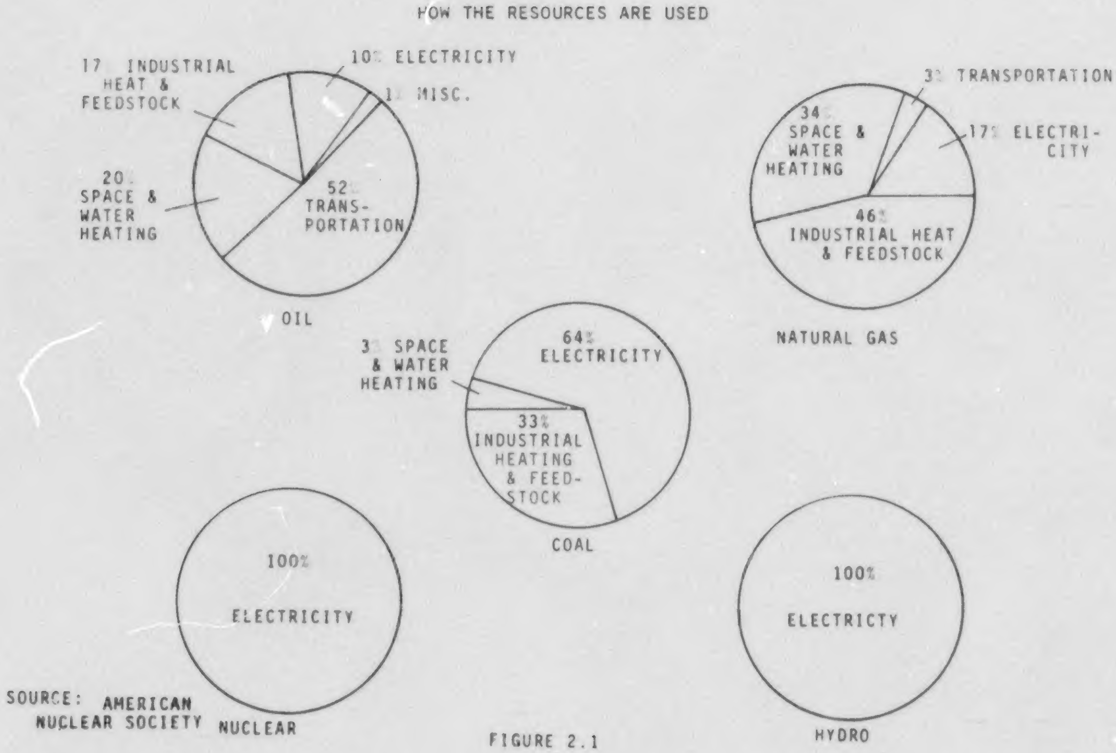
UNIT II

INDUSTRIAL ENERGY--USE AND CONSERVATION

LECTURE	ACTIVITIES
The same forces which are reshaping our views and uses of energy in the residential/commercial areas are at work in the industrial/agricultural segment of our society. The modern industrial society consumes large amounts of energy. As fossil fuels inevitably run out, hard decisions regarding allocations of dwindling supplies will have to be made. It is also possible to make considerable savings through various energy conservation measures in industrial/agricultural areas. Industrial consumption of energy now amounts to about 35 to 40 percent of the nation's total energy budget, with the higher value including the electricity purchased from utilities for driving various motors and for certain electrolytic processes. This is a far higher consumption than in any other segment of the economy, so savings made in this area are very significant. In just two areas of industrial energy use--direct heating and the production of steam--about 27 percent of the nation's energy is used. This is slightly more than is used in all forms of transportation. The primary uses of this energy are in production of metals (particularly iron, steel, aluminum, and copper), refining petroleum, and production of basic chemicals, textiles, food, glass, and concrete.	

The source of this industrial energy is almost totally from the various fossil fuels: coal, petroleum, and natural gas. Slightly more than 50 percent of all the energy used by industry is provided by natural gas. Industry consumes about 50 percent of the natural gas, 20 percent of the petroleum and 35 percent of the coal used in the United States. (Figure 2.1.) It is important to note that while industry consumes about 35 percent of the coal (with much of the remainder being consumed in the generation of electricity) this consumption of coal accounts for only 16 to 18 percent of the total energy used by industry. Most of the coal used today by industry is used in the production of primary metals, particularly steel. Just a few decades ago, coal was the primary fuel for industry, but competition from natural gas and petroleum products has resulted in a rapid decline in the use of coal. Difficulties associated with coal use have encouraged the use of natural gas and petroleum products. Coal creates more air pollution, requires larger storage facilities, and necessitates ash disposal methods. Moreover, coal use is more complicated in operation than gas or oil. These factors work against increased consumption of more available coal and encourage continued use of rapidly depleting oil and gas supplies.

The high dependence of industry on natural gas presents a major problem. As supplies become limited, industrial consumers will be forced to conserve and to switch to less desirable oil and coal. In the future the use of natural gas will likely be restricted to use as a raw material in certain areas and as a fuel only where an especially clean fuel is important. (In the electronics industry and in the direct heating of food products, for example.) Though inevitable, the industrial change away from natural gas



SOURCE: AMERICAN NUCLEAR SOCIETY

FIGURE 2.1

to coal will be both slow and costly because of the changes that will be required in processing systems.

Some mention should be made here about the current switch to coal as boiler fuel for electric generators in many parts of the nation. Companies who would use coal as fuel sometimes face stiff opposition from environmentalists because of the fallout from the smoke stacks (even air scrubbers do not remove all the impurities and there is some pollution). This opposition and the cost factor in converting operations so that coal can be used discourage the change-over to coal.

The major use of petroleum by industry is in the production of chemicals. Forty-three percent of the total industrial use of petroleum is expended in the production of chemicals, with the greatest amount of this petroleum used as raw material, not energy. Petroleum refining accounts for another 26 percent of industrial petroleum use, so, in just these two areas, 69 percent of industrial use, and 12 to 14 percent of the total use of petroleum in this country is accounted for.

There are many ways that small and large industries can conserve energy. A conservation of 20 percent industrial energy today would represent an annual savings equal to the total annual energy consumption 30 years ago.

INDUSTRIAL ENERGY - CONSERVATION:

Figure 2.2 shows the major energy users in industry. Some of the methods that have been used or could be used to conserve energy are as follows: West Germany and other European nations have conserved vast quantities of energy through cogeneration (discussed under Waste Heat Recovery).

MAJOR ENERGY USERS IN INDUSTRY

INDUSTRY GROUP	TOTAL ENERGY %	ELECTRICITY %
PRIMARY METALS	21	23
CHEMICAL & ALLIED PRODUCTS	20	29
PETROLEUM REFINING & RELATED INDUSTRIES	11	4
PAPER & ALLIED PRODUCTS	5	5
FOOD & KINDRED PRODUCTS	5	6
STONE, CLAY, GLASS & CONCRETE PRODUCTS	5	5
TOTALS	67% OF TOTAL ENERGY	72% OF TOTAL ELECTRICITY

ENERGY INTENSIVE INDIVIDUAL INDUSTRIES

INDUSTRY	SPECIFIC FUEL CONSUMPTION (MILLION Btu/kg)	PERCENTAGE OF INDUSTRIAL SECTOR FUEL
IRON & STEEL	29.1	15.2
PETROLEUM REFINING	4.8	11.4
PAPER & PAPERBOARD*	27.0	5.4
ALUMINUM	170.5	2.8
COPPER	28.4	0.4
CEMENT	8.7	2.5
TOTALS	268.5%	37.7 % OF TOTAL USE

*DOES NOT INCLUDE HEATING VALUE OF WASTE PRODUCTS

SOURCE: NSTA FACTSHEET NO. 10. ENERGY CONSERVATION--INDUSTRY

FIGURE 2.2

ENERGY MANAGEMENT

Several large commercial organizations (e.g., Dow Chemical, DuPont) now offer energy-management advice to other companies. DuPont, for instance, decreased its Btu input per unit of product by 25 percent over the past decade and claims to have helped 91 other industries save $13 million in energy costs.

It is estimated that savings of 15 percent (without appreciable capital expenditures) are available immediately. With program redesign and some technological improvement, an additional 10 to 15 percent can be saved in the next five years, and 10 to 20 percent more over the following five to 20 years.

WASTE HEAT RECOVERY:

Major accomplishments will most likely be in the area of utilization of presently wasted heat or more efficient combustion. Heat is a necessary ingredient for many industrial processes, but much of it is wasted or used inefficently. In the metals and glass industries, for example, significant amounts of energy are exhausted up the furnace stacks. The U.S. Department of Energy's Conservation Office estimated that 7 Q* Btu of high temperature heat energy is used for direct heating at an efficiency of only 20 percent. The heat in waste gases, cooling process water, and in hot stock may be retained, converted to steam, and utilized in a turbine drive that can either generate or subsititute for electricity. It may become feasible to recover low temperature waste heat from industrial operations and use this for residential space and hot water heating. In Scandinavia, relatively low temperature (60 C/140 F) waste heat from papermaking machines is collected and used for domestic purposes. This practice conserves their supply of high quality fuels for use other than in the residential sector. This conservation method could be applied in the United States where we often use high quality fuels for residential purposes.

"Co-generation," the simultaneous production of electric power and heat in industrial operations is a powerful energy conservation technique whose development has been slowed by economic and institutional barriers. It is estimated that the energy savings potential of cogeneration could reach 2.1 Q* by the year 2000. Implementation of industrial co-generation will add more than 50,000 Mw of low cost generating capacity (more than the 1976 nuclear capacity) and reduce the need for utility expansion.

(*Quad-10 British Thermal Units.)

Using waste heat to pre-heat combustion gases is one of the most practical conservation methods, and it is currently available. Most furnaces are supplied with air (necessary for combustion) at room temperature. If a furnace which discharges flue gases at a temperature of 2500°F is supplied with air preheated to 1000°F, there can be a savings of about 30 percent in fuel consumption. If the waste gases could be used to preheat the air to 1800°F, the savings in fuel could approach 45 percent.

Other obvious, relatively inexpensive, and still not always used methods of conserving industrial fuel are combustion control devices that insure efficient burning, careful application of good insulating materials to furnaces and boilers, and the elimination of unneccessary cold air leaks.

RECYCLING:

Figure 2.2 also suggests the conservation potential of recycling. Recycling could save 200 M (million) Btus per ton of aluminum, 12 M Btus per ton of steel, and 42 M Btus per ton of copper. According to EPA, 60 to 75 percent of aluminum used in this country could be recycled (4 percent is presently) and 90 percent of the steel (1.4 percent is at present).

A large percentage of solid waste is paper; if recycled, it requires only about one quarter the energy of virgin wood pulp. Although the amount of recycled paper used in the paper industry has decreased from 35 percent of the 1944 total to only about 20 percent now, its use is showing signs of growth. There are now several mills producing paper from waste paper and its use--and energy savings--is increasing.

Other valuable materials are wasted. Much of the waste from plastic manufacture has fuel value. Carbon monoxide is discharged in large quantities by several basic industries (e.g., iron smelting, aluminum and phosphorous production). The feasibility of using this as a raw material for plastic manufacture is under investigation.

A specific example of recycling which shows the savings that can be obtained is in the "coil coating industry" which produces painted steel coils for appliance manufacture. Past practice has been to spray-paint the coils and dry them in a natural gas-fired oven. In one experiment, paint solvents, which normally go up the stack as pollutants, are recaptured and burned to provide heat for the drying ovens. The use of natural gas in this plant was reduced by two-thirds.

MODULE II

SURVEYING ENERGY USAGE

UNIT III

AGRICULTURAL ENERGY--USE AND CONSERVATION

UNIT OBJECTIVES

1. Appreciate the sources and amount of energy required to produce food and services through agriculture.
2. Understand the importance of agriculture in the U.S. being "energy intensive" and the influence it has had on this field.
3. Recognize the correlation between number of people fed and the amount of land and energy required _per capita_.

MODULE II

SURVEYING ENERGY USAGE

UNIT III

AGRICULTURAL ENERGY--USE AND CONSERVATION

LECTURE	ACTIVITIES

In any discussion of agricultural energy use and conservation, one point should be strongly emphasized: as practiced in the United States today, agriculture is energy intensive, not labor intensive. Machines of all sorts powered by diesel or gasoline engines have replaced both manpower and animal power on the farm. Only through this substitution of fossil fuel energy for man and animal power has the American farmer has been able to not only provide us what probably is the best (and certainly the most varied) diet in the world, but also to produce a surplus of some commodities for export to other areas of the world.

This surplus is not, and never will be, sufficient to feed the entire world. Most people in the world today do not receive an adequate amount of food containing the proper distribution of proteins, carbohydrates and fats. As the energy crisis worsens, persons in the emerging, but still underdeveloped, nations see continued inadequate food supply as a major problem. A significant difficulty is the shortage of fertilizer, which, when properly applied, is important in achieving high crop yields. The production of fertilizer, however, requires energy that is in short supply in all underdeveloped nations. This shortage of energy also means less energy to manufacture farm machinery, and less energy to run the machinery if it is manufactured.

The total amount of energy used directly in agriculture is not of great significance in our total energy budget. Food, however, is essential, and agriculture gives a good example in the energy field of the ecological adage that "everything is connected to everything else."

The agricultural energy budget is certainly part of the industrial energy budget. Manufacturing chemical fertilizers, and manufacturing concrete and steel used in dams to impound water for irrigation purposes are but two obvious examples. All the processing and packaging of food also comes under the industrial energy budget.

The transportation energy budget involves moving materials both to the farm and away from the farm. There is still more interconnection with the commercial energy budget as most of the food eventually reaches the public through stores and supermarkets. Could the population of this country (225 million plus) be fed today with the agricultural practices of 100 or even 50 years ago? If it had to be, how much would we have to eat, what would it likely be, and what would happen to the cost?

It might be useful to select some items of diet (hamburger, for example) and briefly trace the energy inputs before the food appears in the kitchen or is purchased at the local hamburger stand.

Early agriculture was a boon to mankind because one man could produce more calories of food value than the calories of energy expended. With moderately advanced agriculture methods using animal power, the sum of man and animal energy was still exceeded by the caloric energy of the produced food.

Today, for many high-profit but low-energy crops (such as melons, tomatoes, onions and other low calorie fruits and vegetables that require spraying, fertilizing and cultivation to produce a good crop), far more calories of fossil fuel energy are consumed in producing these crops than there are calories of food energy in the crops produced.

There are a number of ways in which energy conservation can be achieved, and every barrel of oil or its equivalent saved is important. If some is good, more may not be better, and over-fertilizing fields is a waste of energy. Far more use should be made of organic fertilizers. Manure from feed lots and from chicken and turkey farms is often considered only a problem to be disposed of rather than a useful by-product.

IMPACT OF POPULATION GROWTH

ON AGRICULTURAL PRODUCTION

FOR EACH 1⅛ MILLION NEW PERSONS ADDED TO OUR POPULATION FARMERS MUST PLANT OR RAISE AN ADDITIONAL:

- 5000 ACRES OF POTATOES
- 3000 ACRES OF TOMATOES
- 2600 ACRES OF ORANGES
- HAY, GRAIN, AND PASTURE FOR 130,000 BEEF CATTLE AND 80,000 DAIRY COWS
- 200,000 THANKSGIVING TURKEYS

OR AT LEAST INCRESE PRODUCTION BY AN EQUIVALENT AMOUNT.

THE INCREASED ENERGY CONSUMPTION TO PRODUCE THESE INCREASED AMOUNTS OF FOOD WILL REDUCE THE NUMBER OF YEARS THAT OUR ENERGY SUPPLIES WILL LAST.

SOURCE: THE SQUEEZE, U.S. DEPARTMENT OF AGRICULTURE

FIGURE 3.1

A discussion of agricultural energy problems provides an opportunity to introduce the effects of increasing population on the energy problem. If our population grows by only 1/2 of 1 percent (.5%) per year, we will add just over 1,125,000 new persons annually. When these people take their places at the nation's dinner tables, and if they are to enjoy the same diet that we have enjoyed, farmers will have to plant another 5,000 acres of potatoes, 3,000 acres of tomatoes and 2,600 acres of oranges. (Figure 3.1 shows these statistics). They also must raise hay and grain and provide pasture for 130,000 additional beef cattle and over 80,000 dairy cows. And, when that additional 1.125 million people want to have turkey for Thanksgiving, about 200,000 more birds. Each of these items, and all the other agricultural items that go into our diet, require energy. If we are going to have the energy available to provide not only our food but our other necessities, we must both conserve in all possible ways and simultaneously increase our research and development of alternate energy sources and more efficient use of fossil fuels.

MODULE II

SURVEYING ENERGY USAGE

UNIT IV

TRANSPORTATION: ENERGY USE AND CONSERVATION

UNIT OBJECTIVES

1. Recognize the importance of transportation to the economy of any nation.
2. Discuss the amount of the nation's energy budget which goes for transportation.
3. Appreciate the energy consumption of the automobile versus car pooling and public transportation.
4. Recognize and discuss problems associated with energy conservation measures in transportation.
5. Be aware of proposed solutions for making transportation in the U.S. more energy efficient.
6. Discuss alternate fuel solutions to fossil fuels for use in transportation.

MODULE II

SURVEYING ENERGY USAGE

UNIT IV

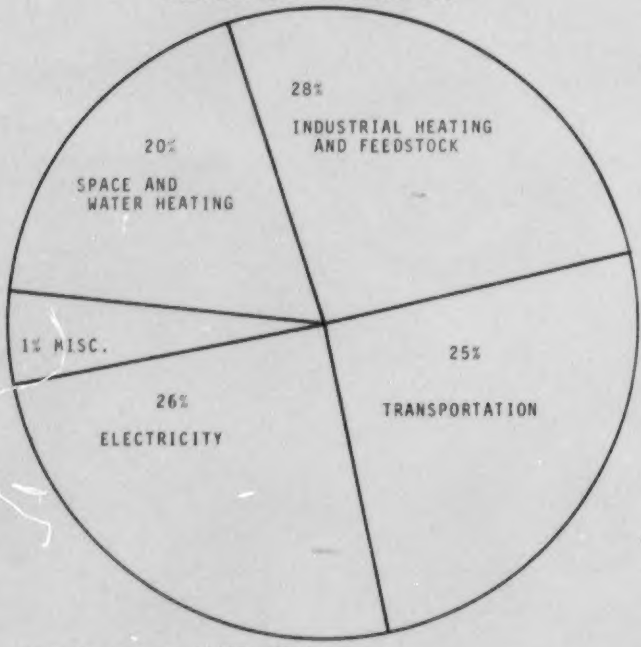
TRANSPORTATION: ENERGY USE AND CONSERVATION

LECTURE

The transportation segment of the economy of the United States currently consumes about 25 percent of the nation's energy budget. About 77 percent of the transportation energy (or about 20 percent of our total energy) is used by highway vehicles. Commercial and industrial trucks and buses use about 20 percent of the energy and private automobiles consume most of the remaining 57 percent. In terms of the nation's total energy budget, some 15 percent is used to power private vehicles. (Figures 4.1 and 4.2)

ACTIVITIES

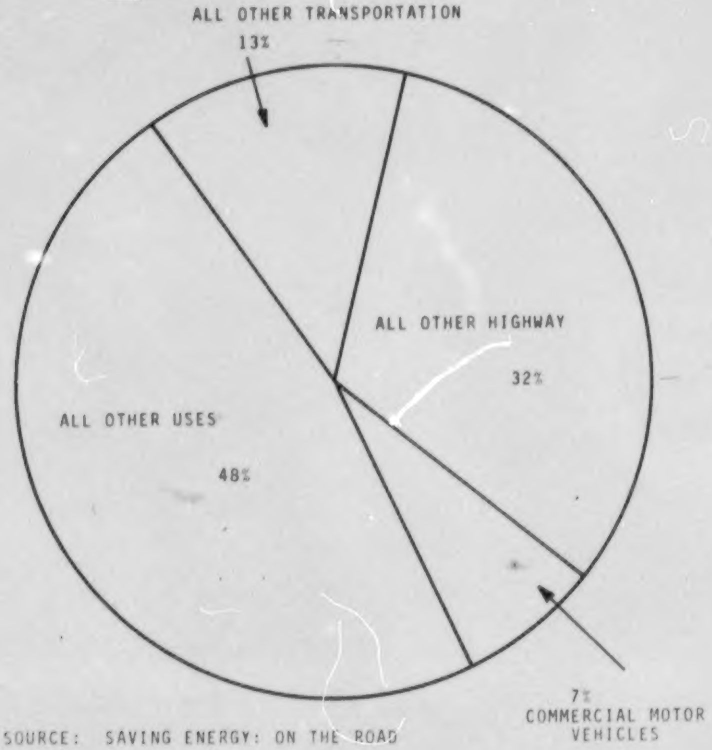
DISTRIBUTION OF ENERGY USE



SOURCE: WHY AN ENERGY CRISIS?

FIGURE 4.1

TOTAL U.S. PETROLEUM CONSUMPTION--1973



SOURCE: SAVING ENERGY: ON THE ROAD

FIGURE 4.2

Trains, boats of various types, and planes account for about 23 percent of the transportation energy or about 6 percent of the total energy budget of the nation. In the case of trains and boats, the largest amounts of energy are used in transporting both high bulk and high weight raw materials and finished products. Though we normally think of planes in terms of transporting people, freight transport is also significant, particularly when delivery speed, perishability of cargo, and light-weight or high-value shipments are involved. The fact that these types of transportation consume only 23 percent of the transportation energy budget suggests that most discussion should concentrate on both use and conservation of energy in the highway transportation segment.

Highway transportation involves several distinct areas, each with its own energy demand and varying conservation possibilities. Private and commercial industrial vehicles play different roles in the economy and, likewise, in any discussion of energy. Where and how these vehicles are being used is also significant, and must be considered in any energy plan.

THE AUTOMOBILE:

Private automobile use consumes 15 percent of the nation's energy budget, and the vast majority of individuals are personally responsible for at least some small part of that use. It seems unlikely that the American public will be separated from the private automobile. The private car is an integral part of our life-style and of the economy. What may have to change is the way in which the private automobile is used. In Boston for five to six days following the great blizzard of February 6-7, 1978, no private vehicles were permitted on roadways within about 15 miles of the city. More public transportation was made available, work hours were staggered, and the public coped. Most people walked more in four days than they normally do in a month, and their health was not harmed. Once private travel was again permitted, however, cars appeared like ants from an ant hill and public transit service was reduced.

In most large cities, public transit has deteriorated since 1950 as more automobiles have come into use. Freeways and toll roads have used former commuter rail rights-of-way, and parking lots and garages have proliferated. Traffic congestion is an accepted part of life. Can limits be imposed on the use of private cars? Can cars be banned from certain roadways at certain times? Can a higher occupancy rate be required during certain hours? Will it be necessary to impose limits of these or other types? These kinds of questions should provide some heated, but potentially useful, discussion.

It might be well to note that our freedom is already limited in certain ways. Traffic lights and speed limits, STOP signs and NO PARKING zones limit our freedom to do as we please when such "doing" would be harmful to ourselves and others. Water restriction is common in areas of limited supply. Should we expect less in the area of transportation as the energy crisis worsens?

Van pooling is being tried in a few major cities. During peak hours, certain lanes of traffic are reserved for those commuters involved in a van pool. Van pooling and car pooling are less difficult to arrange if places of employment provide a system of matching riders and locations.

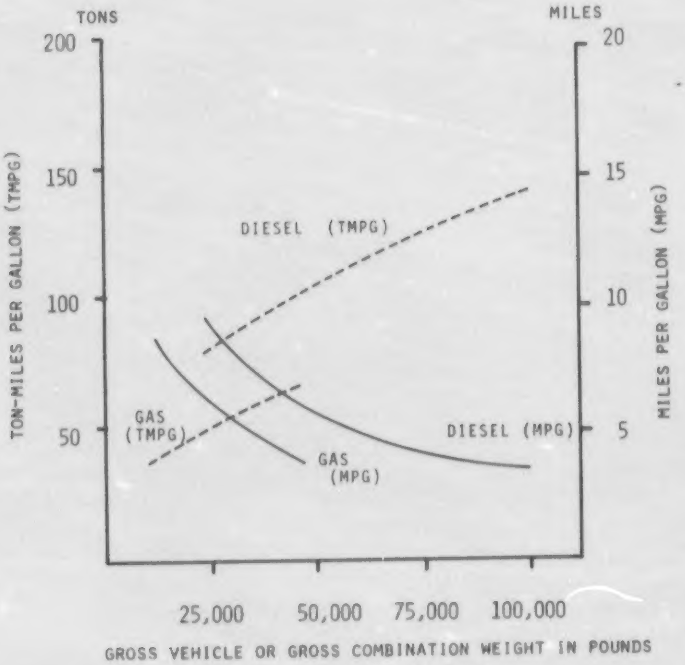
The movement of people occurs in many varied situations--commuting to and from places of employment, general travel within a city or suburban area, travel between cities, and vacation travel, to name a few. To illustrate this idea, ask the students to list all the different purposes for which they traveled during the past week and the method by which the travel was accomplished (example: went to doctor--car; went to work five times--bus; picked up a quart of milk--walked). A quick compilation on the blackboard will show the many different kinds of movements people make. A similar situation exists for the movement of goods. There are vast differences in transportation and energy problems associated with in-town delivery trucks, oil delivery trucks, and freight carriers in inter-city or cross-continent deliveries.

Some of the major cities and some rural areas are trying out the use of mini-buses for use by senior citizens to commute to shopping plazas and doctor's offices. Churches and private organizations are attempting to alleviate the transportation problem by running their own buses. Many large hotels in tourist areas are furnishing bus transportation from the airport to the hotel and from the hotel to nearby attractions for a nominal fee.

REGULATIONS VS. ECONOMY

Often, regulations are passed that control many parts of the transportation industry, and the effects may be both positive and negative. The nationwide 55 m.p.h. speed limit can be discussed as an example of this. There is no question that a 55 m.p.h. (or even 50 m.p.h.) speed limit on automobiles, small trucks, and vans results in considerable savings of energy. The standard car engine will produce 3-5 more miles per gallon at 50 m.p.h. than it will at 70 m.p.h.--a fairly common travel speed when limits were 65 m.p.h. Large tractor-trailer trucks, however, may achieve no economy at the lower speed and will probably achieve fewer ton-miles per gallon of fuel used. Ton miles are a much better measure of economy for heavy freight transport than simply miles per gallon. Energy per ton-mile is that amount of energy (usually derived from fossil fuel) required to move a ton of payload one mile. In figuring overall economy per ton-mile, driver and equipment costs are considered as well as fuel costs. (See figure 4.3) Economic energy consumption on heavy diesel trucks is usually greatest when steady speeds can be maintained and down-shifting and acceleration are kept to a minimum. In many areas of the country, a 55 m.p.h. speed limit forces gear changing and loss of economy. Should trucks be allowed a higher speed limit than cars if a higher limit is more economical? Should special lanes be

APPROXIMATE PRODUCTIVITY IN TON-MILES PER GALLON
VS. FUEL ECONOMY IN MILES PER GALLON



UNLIKE PRIVATE PASSENGER VEHICLES, LARGER VEHICLES (EITHER GASOLINE OR DIESEL POWERED) PRODUCE MORE EFFICIENT TRANSPORT IN TON-MILES PER GALLON AT WHAT APPEARS TO BE A LESS ECONOMICAL MILES PER GALLON FUEL CONSUMPTION.

(A TON-MILE PER GALLON IS THE NUMBER OF TONS THAT CAN BE HAULED ONE MILE ON A GALLON OF FUEL.)

SOURCE: INNOVATION IN PUBLIC TRANSPORTATION

FIGURE 4.3

set aside for truck use? What safety problems could exist if large, heavy trucks were continually passing much slower-moving automobiles? Is it fair to have different speed limits for different kinds of vehicles?

Generally speaking, water transportation is the most efficient per ton-mile; rail transportation is second. Highway transportation is the most common, but ranks third in efficiency, while air freight is the least efficient per ton-mile. However, one must take into account the urgency and availability of alternate methods of transportation. Transportation by water is quite slow and waterways are limited.

Railroads and highways have limitations also, whereas air transportation is used universally and has many advantages in regard to delivery. Materials may be transported to remote areas and parachuted to depots on the ground. Many days might be required for drivers and trucks to make the same delivery. Whenever practical, industry uses the most economical ton-mile transportation to move raw materials and products.

INTER-CITY TRAVEL

Inter-city travel in the northeast corridor between Boston, New York, and Washington provides another example of transportation problems. Should most of this travel be by plane, or should more of it be by rail? Generally, trains can carry people at less energy cost per mile than planes, particularly for distances of 200-300 miles. Planes are faster, but trains go from central city to central city, and eliminate trips to and from airports. During the past 25 years, while toll and inter-state highways have been constructed between Boston and New York, and new and improved facilities made available at airports in each city, little or nothing has been done to improve rail transportation. Today, the rail time between Boston and New York is the same 4-5 hours that it was in 1950, but high speed (150 m.p.h.-plus) trains operate in Japan and in other countries. We must also ask how many choices of departure and arrival times are really needed between cities. Would less-frequent service really be detrimental if the results were higher load factors and more economical use of energy? (Urban participants should be urged to find out the frequency of service by bus, plane, and rail into and out of their city relative to other cities 50-300 miles distant. Consumer use at different times of the day should also be determined, if possible.)

COMMUTER PROBLEMS

One of the most complicated problems, and one which today is perhaps most wasteful of energy, is the movement of people to and from work--the commuter problem. Though the automobile is widely used for this purpose, clearly such a system is not ideal. Traffic jams, frayed nerves, and numerous "fender bender" accidents are evidence that the system is not effective. The use of aerial patrols reporting the best or worst road conditions over radio stations in almost every city is further evidence that automobile commuting is inefficient. Studies carried out in the past few years indicate that commuting by automobile generally consumes about three times as much energy per passenger-mile as is required for public transit. In more widely dispersed suburban areas where population densities would not permit effective public transit, transportation by automobile to a suburban transit stop and completion of travel by public transit could result in about 50 percent savings in energy rather than a 66 percent savings for a total public transit ride. Clearly, a variety of efforts will have to be made to improve energy use in the many aspects of the transportation industry. Discuss efforts being made in your community.

PROPOSED SOLUTIONS

There are a number of significant steps that can be taken by almost everyone to aid in the conservation of energy in the area of transportation. Since the movement of people consumes most of the energy expended for transportation, it is here that the greatest conservation efforts should be placed. Because it seems unlikely that it will be possible to separate the consumer from the automobile, a strenuous effort must be made to improve the driving habits of motorists. While professional drivers in "economy runs" often get 50 percent more miles per gallon than the average driver, almost every driver could reduce fuel consumption by 10 to 20 percent with no reduction in miles traveled. Two steps may be taken to accomplish much of this fuel saving: (1) keep the vehicle properly maintained, and (2) practice good driving habits.

CONSERVATION, REGULATIONS, DRIVING HABITS AND ENGINE CHANGES

Changing the driving habits of millions of motorists will not be easy. Participants in this course, however, can prove to themselves that energy can be saved in this manner. While it is important to accelerate to high gear briskly, "jackrabbit" starts can cost as much as 50 percent more in fuel. Think in terms of having an apple on the hood and accelerate in a manner that would keep the apple on the hood. Rushing ahead at stop lights often results in forced stops at the next light, thus wasting fuel in "jackrabbit" starts and losing momentum by having to brake at the next light. The lighter the foot on the gas pedal, the better the fuel economy.

In highway driving, when travel speed is reached, ease off the accelerator. A steady speed is much more fuel efficient than one that fluctuates. EPA tests show that cruise controls on passenger cars conserve fuel. One of the worst highway driving habits is tailgating. Tailgating is not only dangerous but, in most cases, costs fuel in that it forces you to drive with the same habits as the person in front. With adequate space between vehicles, gradual speed adjustments can be made. When approaching a hill, gather momentum so that the hill can be climbed without undue pressue on the accelerator; when descending, take pressure off the accelerator slightly to take advantage of gravity. In driving where there are traffic signals, anticipate the changes and slow down long before reaching a red light.

Efforts are being made in many directions to improve the efficiency of vehicles. One of these efforts, strictly in the experimental phase, is flywheel energy storage (illustrated in Figure 5). The principle has been applied to some subsidiary electric transit vehicles and is being investigated for application to electric transit buses and delivery vehicles. Electric vehicles used primarily in urban traffic waste large amounts of energy because frequent stops are required.

Left-foot braking is costly to the consumer. Most people who brake with their left foot keep it there most of the time, especially while driving in traffic. Even a slight pressure on the brake while the other foot is on the accelerator puts added strain on the engine, with consequent loss in efficiency. (Suggest to the participants that they observe how frequently they see brake lights on the car in front of them when braking is clearly unnecessary and obviously not being done to slow the car.)

A very effective way of conserving gasoline is to install a vacuum gauge and drive at a steady speed. A vacuum gauge will show immediately when one is over-accelerating. A gauge can be purchased for as little as $4 and is quite simple to install.

Gas mileage increases from good driving habits can easily be translated into dollar savings. For some drivers, this could be as much as $100 per year. More importantly, even a 10-15 percent reduction in gasoline consumption by private vehicles would save about three percent of the nation's total energy budget, with no significant reduction in miles driven.

During normal braking, much of the "stopping energy" is dissipated as heat. This braking energy can be converted into flywheel energy, which can then be used for acceleration or converted into electrical energy, stored, and used for later acceleration. Considerable fuel savings should be obtained when this flywheel energy storage system is perfected. However, there might be a loss in net energy when one considers the extra material that must be manufactured to install the equipment.

Diesel engine developments are providing a new and more frequently used power source for small vehicles such as light trucks, vans, and passenger cars. Though the initial cost is higher, it is felt that this cost is more than returned in lower fuel costs with an overall saving in energy.

The current EPA mileage ratings of vehicles, and the use of these ratings in advertising, indicate that more economical vehicles can be produced and that economy is of concern to many people. In most cases, the concern is only with the dollar cost of fuel, not the consumption in gallons. Whatever the motivation, the effect is the same.

ALTERNATIVES TO FOSSIL FUEL

What of the future? All predictions indicate a real shortage of petroleum fuels within 20 years at present consumption rates. Conservation in all areas may extend the run-out time slightly, but not significantly. Thus, there appears at present to be only a single long-range solution to the transportation problem--a new method of propulsion that eliminates the almost total current dependence on fossil fuels.

In the 1970s, the competitive advantage of the internal combustion engine (ICE) began to reverse. Gasoline costs began to climb, and new laws on motor vehicle pollution, safety, and fuel economy curtailed ICE vehicle performance capabilities, increased costs, and influenced vehicle markets to consider alternative forms of motor vehicle transportation.

ELECTRICITY

One possible alternative is the electric motor. This is already in use in certain specialized vehicles such as small lift trucks used in warehouses, and in a few urban vehicles that cover only 20-40 miles per day at relatively low speeds. The major problems with widespread use of electric vehicles are in how to provide an adequate and compact storage system for electrical power on board the vehicle, locating sources of electricity other than fossil fuel to recharge the batteries, and establishing locations for recharging stations. Current technology of battery storage is not efficient for most operations. The weight and bulk of batteries required for most vehicular operations today make the vehicles quite inefficient. New battery technology may solve this problem in the future.

In September 1976, the Congress enacted Public Law 94-413, the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976, to establish a program to stimulate the commercialization of electric and hybrid vehicles as a partial solution to the oil consumption problem. This law, later amended by Public Law 95-238, reflects the seriousness with which Congress views increasing dependence on foreign oil for transportation. The U.S. Department of Energy is supporting extensive research to develop the electric vehicle. Under this congressional act, several thousand vehicles are being built which will provide for wide-scale testing and identification of suitable markets. While it is recognized that at present the electric vehicle has limited use, it could now be used on predictable routes and for people to travel to and from commuter points. The goal is to start the process of establishing an industry so that an efficient electric vehicle can be ready for use when the conventional internal combustion engine cannot meet all transportation needs because of shortage of gasoline or other oil products. It is not expected that in the near future any substantial savings in net energy will result, but the electric vehicle will provide a more flexible source of energy for transportation.

One nation currently taking advantage of electric power for its transportation needs is Taiwan, an island which has an abundance of hydro-electric power and is developing nuclear power. As a result, almost 100 percent of the rail transportation has been electrified.

Though it may appear that changing from petroleum fuel to electric power--still largely produced by fossil fuel generation--would not solve any problems, it must be recognized there are many alternative sources of energy for the production of electricity. Hydro and nuclear energy are, of course, already in use, along with fossil fuel electrical generating plants. Anything that burns could be used to replace the fossil fuel now used in steam generating plants. Slash from forest operations, and urban and industrial wastes are two obvious sources of energy. In Nashville, Tenn., a plant which burns municipal waste provides both heat and electricity for government and some private buildings. Electricity can also be generated via other energy sources. Wind and tidal power are already in use on a small scale, and this use could certainly be expanded. Ocean temperature differences can be used to generate electrical current (OTEC), and it may not be out of the question, 25 years from now, to find that our electrical power is generated in space from large solar panels and then beamed to earth via lasers. The important thing is that there are many sources for electricity other than fossil fuels, and if the storage problem can be solved, then an alternative to the internal combustion engine fueled with fossil fuel would be available.

OTHER COMBUSTION FUELS

Another approach to what to do when the oil runs out is to develop a different fuel for essentially the same type of internal combustion engine. Both methane gas and alcohol are fuels that have already been used to power vehicles. Both can also be manufactured from organic sources other than the fossil fuels. Both of these fuels also produce some of the same types of pollutants that are associate with the fossil fuels.

Still another potential fuel for powering the internal combustion engine is hydrogen gas. With the exception of space vehicles, most hydrogen-burning engines have been experimental. As with other fuels, problems exist that would have to be overcome--the problem of explosion and/or fire --but that also exists with gasoline, alcohol, and methane. The problem may be greater, but it is still also open to solution. Another problem would be manufacturing large quantities of hydrogen gas. Currently, such production would likely be done by breaking down the water molecule (H_2O), using electrical energy. Clearly, the great amount of electricity necessary would have to be provided by nonfossil fuel sources.

One distinct advantage of hydrogen fuel would be the virtual elimination of the air pollutants produced by fossil-fueled, internal combustion engines. The major product produced when hydrogen is burned is water vapor. Though on cool days we might see a small plume of condensed vapor extending from the exhaust of each vehicle, this vapor would certainly be preferable to the pollutants now produced by vehicles in our urban areas.

Methane is a gas that also has potential as fuel. It is clean-burning, but has a relatively low Btu production. The Japanese and Germans used it as fuel in World War II. The United States is now looking at it because it often is a by-product of organic decomposition. Through a process known as pyrolysis, methane is produced in several modern solid waste disposal plants. It is then sold or burned to generate electricity.

Several inventors have developed novel vehicles powered by methane generated from animal feces. The generator is usually in the trunk of the vehicle. While the feces generated methane vehicle is little more than a fad, methane-powered engines have been used in oil fields for years. Few mechanical changes are needed to convert gasoline engines into gas engines. Since natural gas is in short supply, methane will not become a widely used fuel unless large quantities are produced through pyrolysis or some other bioconversion method.

The instructor has a unique opportunity in this module to introduce the students to many of the more interesting technical developments that have come about in response to our changing energy resources. Some of the developments that could be discussed in connection with energy conservation are; solar heating, underground and semi-underground residences, hydroponic gardening (gardening without soil, feeding the plants with a liquid solution of nutrients), solar greenhouses, ocean thermal power, wind power, magnetic and vacuum rail travel, enclosed and underground cities, methane powered automobiles, other methane uses, tidal power, energy from waste, and many more.

MODULE II

SURVEYING ENERGY USAGE

POSTTEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. Only about 10 million single-family homes in the United States are inadequately protected from outside weather.

   a. true b. false

2. Fossil-fueled generators supply eighty percent of the electricity produced in the United States.

   a. true b. false

3. Most of the energy used in our households is used for heating water and cooking.

   a. true b. false

4. The Federal Housing Administration regulations call for at least an _______ of insulation in attic floors or over top floor ceilings in new houses.

   a. R-30
   b. R-10
   c. R-19
   d. R-5

5. For every degree the average temperature above 70°F is reduced in a home, savings of from 2 to 3 percent are normal.

   a. true b. false

6. About 15 million single-family homes have no attic or ceiling or top floor insulation.

   a. true b. false

7. By reducing the hot water temperature by 10°F, a _______ percent reduction in energy consumption can be accomplished.

   a. 2
   b. 6
   c. 10
   d. 20

8. Most hot water tanks are set for _______ °F water.

   a. 100
   b. 120
   c. 140
   d. 200

9. Unless a dishwasher is used, a hot water temperature of 120°F is usually adequate.

   a. true   b. false

10. It is not important to keep fireplace dampers closed when the fireplace is not being used.

   a. true   b. false

11. In industry, _______ percent of the nation's energy is used in direct heating and the production of steam:

   a. 10
   b. 20
   c. 27
   d. 57

12. Nearly 50 percent of all the energy used by industry is provided by natural gas.

   a. true   b. false

13. Industry consumes about 35 percent of all the coal used in the United States.

   a. true   b. false

14. Industrial consumption of energy now amounts to about 35 to 40 percent of the nation's total energy budget.

   a. true   b. false

15. The standard car engine will produce _______ more miles per gallon at 50 m.p.h. than it will at 70 m.p.h.

   a. 10-15
   b. 3-5
   c. 8-10
   d. 1-2

16. The private automobile consumes about 15 percent of the nation's energy budget.

   a. true   b. false

17. The total amount of energy used directly in agriculture is not of great significance in our total energy budget.

   a. true   b. false

18. The recycling of such materials as paper does little to save energy.

   a. true   b. false

19. _______ to _______ percent of the aluminum used in this country could be recycled:

    a. 10 - 20
    b. 30 - 40
    c. 50 - 60
    d. 60 - 75

20. The major use of petroleum by industry is in the production of steel.

    a. true   b. false

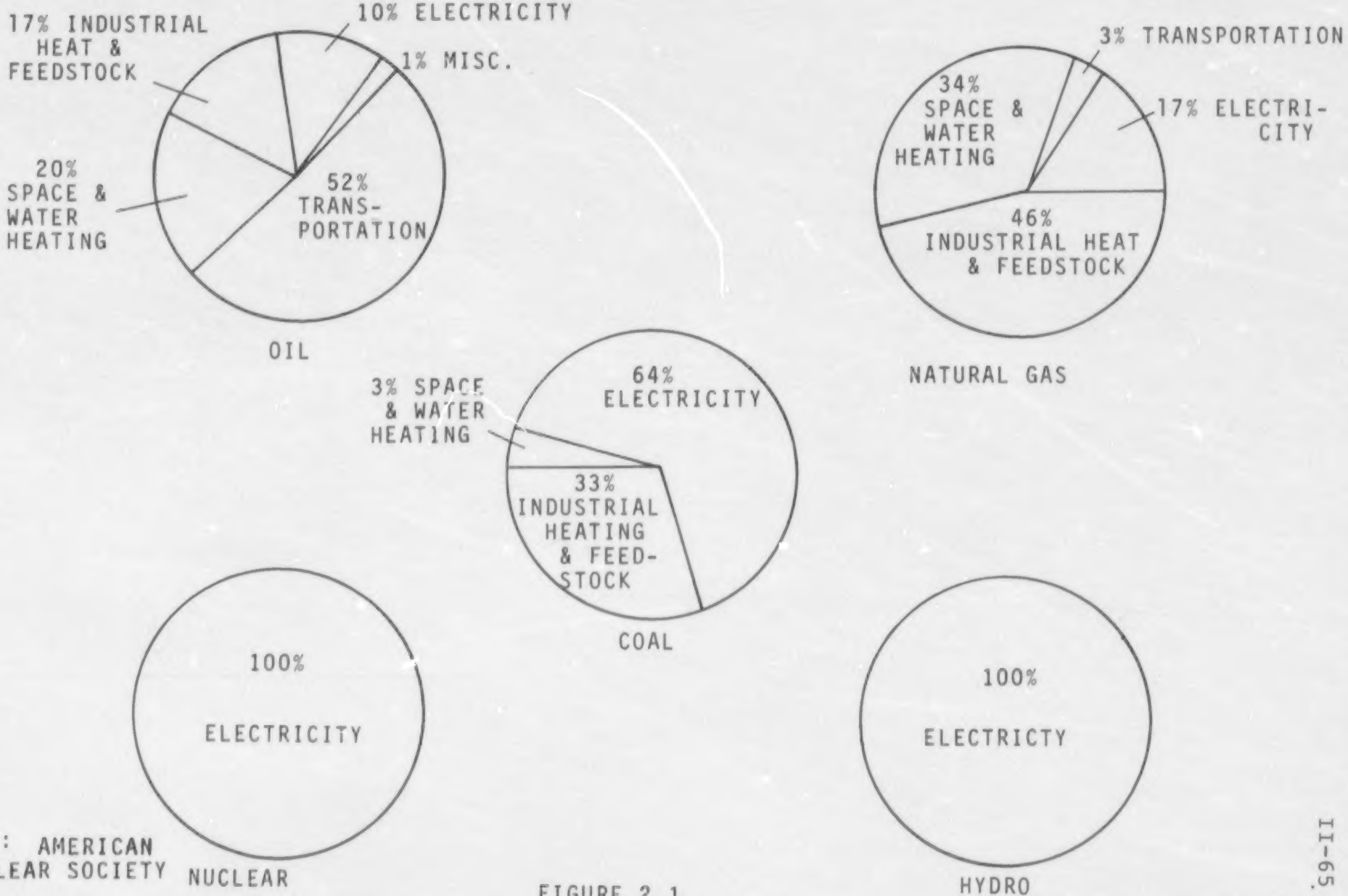
MODULE II

SURVEYING ENERGY USAGE

ANSWERS TO POSTTEST

1. b. false
2. a. true
3. b. false
4. c. R-19
5. a. true
6. a. true
7. b. 6
8. c. 140
9. a. true
10. b. false
11. c. 27
12. a. true
13. a. true
14. a. true
15. b. 3-5
16. a. true
17. a. true
18. b. false
19. d. 60 - 75
20. a. true

HOW THE RESOURCES ARE USED



SOURCE: AMERICAN NUCLEAR SOCIETY

FIGURE 2.1

MAJOR ENERGY USERS IN INDUSTRY

INDUSTRY GROUP	TOTAL ENERGY %	ELECTRICITY %
PRIMARY METALS	21	23
CHEMICAL & ALLIED PRODUCTS	20	29
PETROLEUM REFINING & RELATED INDUSTRIES	11	4
PAPER & ALLIED PRODUCTS	5	5
FOOD & KINDRED PRODUCTS	5	6
STONE, CLAY, GLASS & CONCRETE PRODUCTS	5	5
TOTALS	67% OF TOTAL ENERGY	72% OF TOTAL ELECTRICITY

ENERGY INTENSIVE INDIVIDUAL INDUSTRIES

INDUSTRY	SPECIFIC FUEL CONSUMPTION (MILLION Btu/kg)	PERCENTAGE OF INDUSTRIAL SECTOR FUEL
IRON & STEEL	29.1	15.2
PETROLEUM REFINING	4.8	11.4
PAPER & PAPERBOARD*	27.0	5.4
ALUMINUM	170.5	2.8
COPPER	28.4	0.4
CEMENT	8.7	2.5
TOTALS	268.5%	37.7 % OF TOTAL USE

*DOES NOT INCLUDE HEATING VALUE OF WASTE PRODUCTS

SOURCE: NSTA FACTSHEET NO. 10. ENERGY CONSERVATION--INDUSTRY

FIGURE 2.2

IMPACT OF POPULATION GROWTH
ON AGRICULTURAL PRODUCTION

FOR EACH 1¼ MILLION NEW PERSONS ADDED TO OUR POPULATION FARMERS MUST PLANT OR RAISE AN ADDITIONAL:

5000 ACRES OF POTATOES

3000 ACRES OF TOMATOES

2600 ACRES OF ORANGES

HAY, GRAIN, AND PASTURE FOR 130,000 BEEF CATTLE AND 80,000 DAIRY COWS

200,000 THANKSGIVING TURKEYS

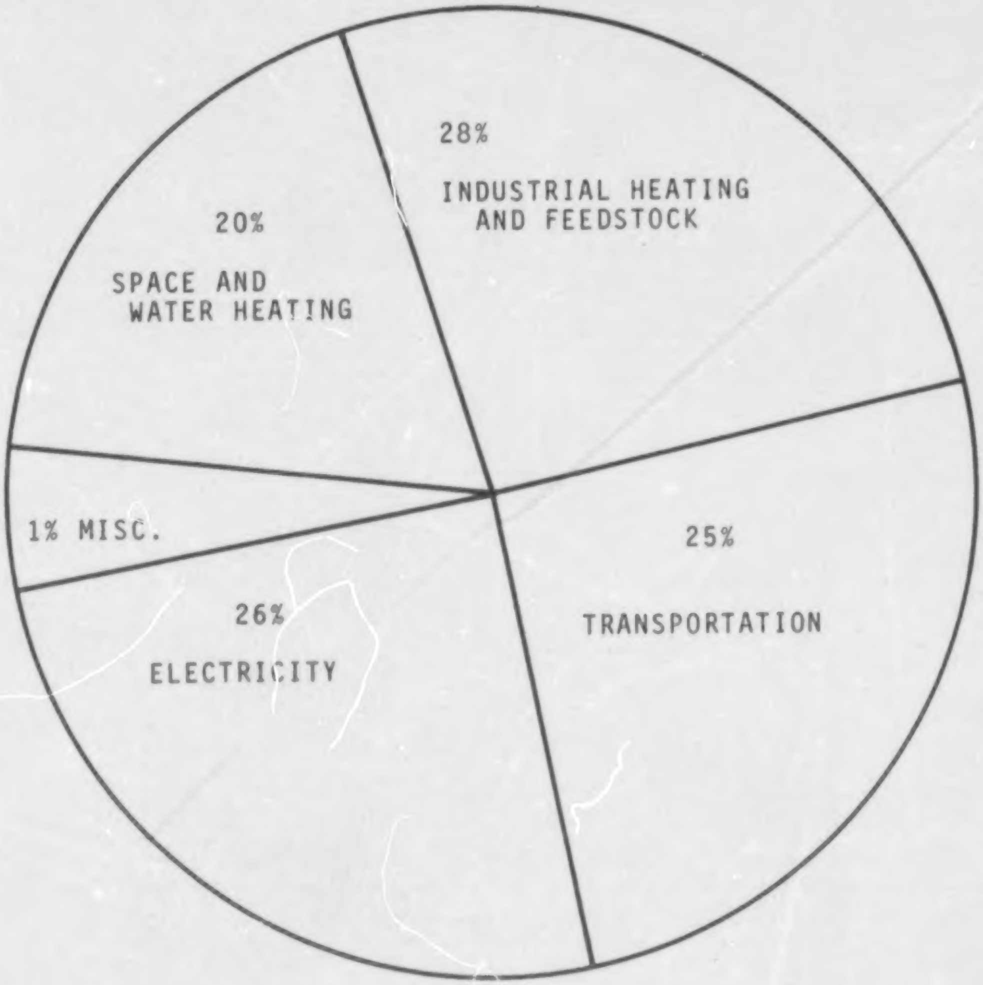
OR AT LEAST INCRESE PRODUCTION BY AN EQUIVALENT AMOUNT.

THE INCREASED ENERGY CONSUMPTION TO PRODUCE THESE INCREASED AMOUNTS OF FOOD WILL REDUCE THE NUMBER OF YEARS THAT OUR ENERGY SUPPLIES WILL LAST.

SOURCE: THE SQUEEZE, U.S. DEPARTMENT OF AGRICULTURE

FIGURE 3.1

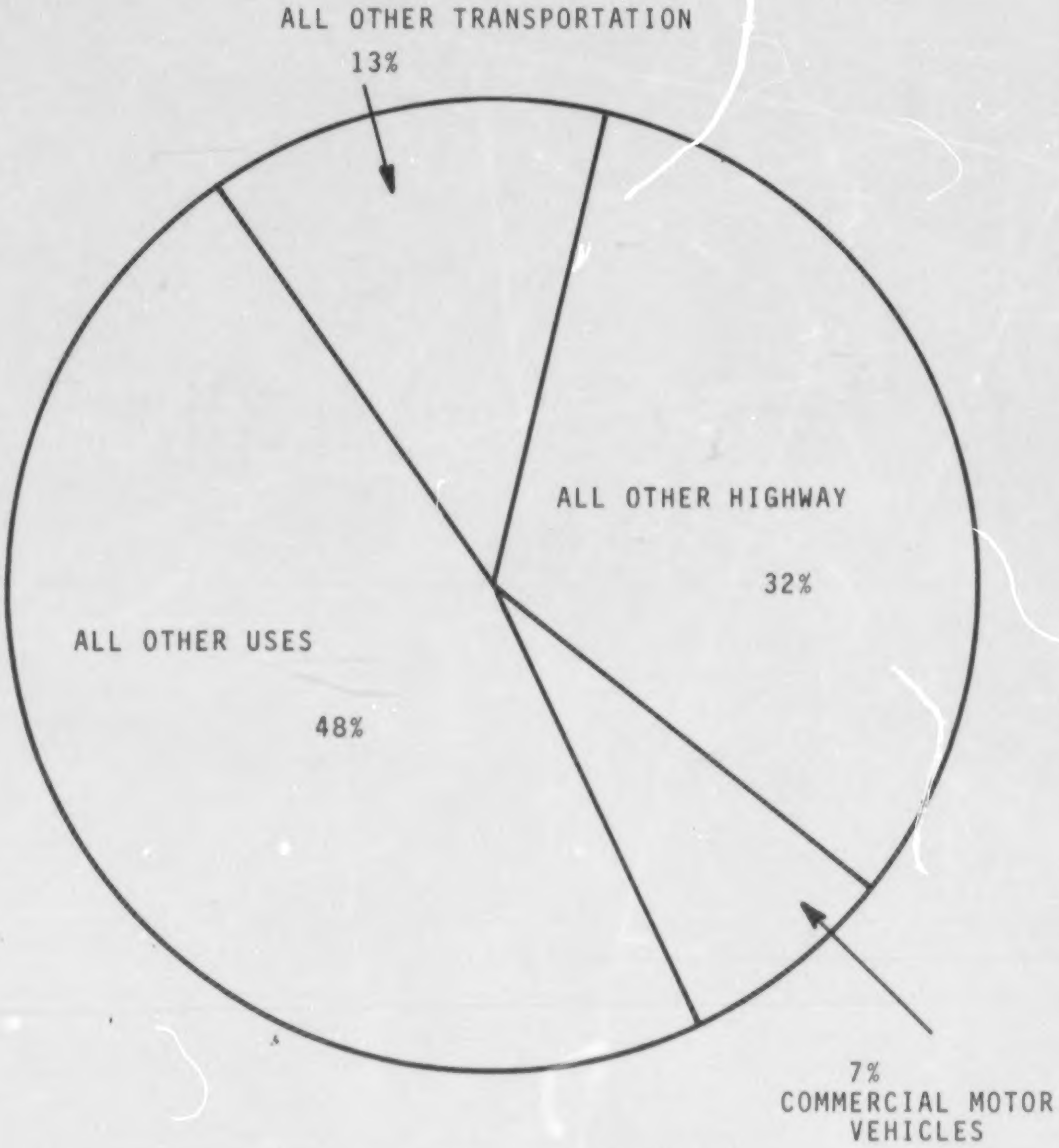
DISTRIBUTION OF ENERGY USE



SOURCE· WHY AN ENERGY CRISIS?

FIGURE 4.1

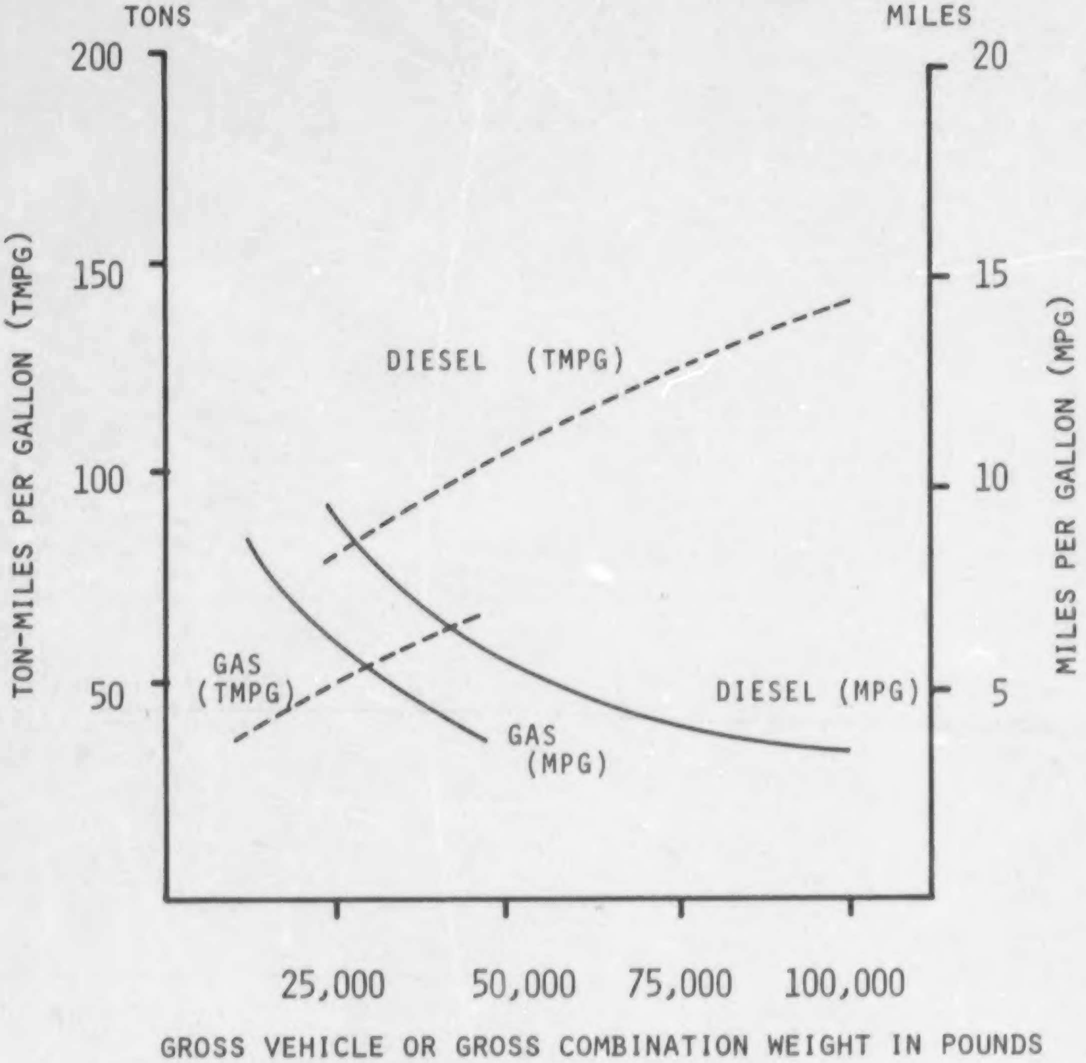
TOTAL U.S. PETROLEUM CONSUMPTION--1973



SOURCE: SAVING ENERGY: ON THE ROAD

FIGURE 4.2

APPROXIMATE PRODUCTIVITY IN TON-MILES PER GALLON VS. FUEL ECONOMY IN MILES PER GALLON



UNLIKE PRIVATE PASSENGER VEHICLES, LARGER VEHICLES (EITHER GASOLINE OR DIESEL POWERED) PRODUCE MORE EFFICIENT TRANSPORT IN TON MILES PER GALLON AT WHAT APPEARS TO BE A LESS ECONOMICAL MILES PER GALLON FUEL CONSUMPTION.

(A TON-MILE PER GALLON IS THE NUMBER OF TONS THAT CAN BE HAULED ONE MILE ON A GALLON OF FUEL.)

SOURCE: INNOVATION IN PUBLIC TRANSPORTATION

FIGURE 4.3

MODULE III

UNDERSTANDING UTILITY BILLS

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. Understanding Utility Bills may be offered independently or as part of a sequence of three modules in the following order:

Order	Module	Title of Module
1	3	Understanding Utility Bills
2	5	Lighting Conservation Opportunities
3	7	Appliance Energy Conservation Opportunities

MODULE III

UNDERSTANDING UTILITY BILLS

MODULE DESCRIPTION:

The student will be introduced to the utility bills used for residential and commercial customers. The electric bill will be discussed in terms of terminology and definition, cost breakout, meter readings, and rate schedules. Natural gas utility bills will be discussed in terms of terminology and definitions, heat content, cost per unit, meter reading, and rate schedules. The types of utility meters will be discussed as monitoring devices for the amount of energy used. Demand meters and energy indicators must be identified and understood in order for the particular knowledge learned to be generalized.

INTRODUCTION:

The American consumer is made aware of the energy he or she consumes by receiving a periodic utility bill. This bill expresses the amount of energy used, the price per unit or rate of charge, and the amount of money due for this expense. The bill is based on the number of utility units used as indicated on the utility meter. In order to monitor the amount of energy used so that energy conservation measures can be evaluated, the student must know how to read utility meters.

READING GRADE LEVELS:

Lecture: 13
Lab : 15

SUGGESTED TEACHING TIMES:

Secondary : 3 hours
Postsecondary: 2 hours

MODULE III

UNDERSTANDING UTILITY BILLS

UNITS:

- I. Electric Meters
- II. Electric Rates
  - A. Meter Rates
    - (1) Straight Line Meter Rate
    - (2) Step Meter Rate
    - (3) Block Meter Rate
  - B. Demand Rates
    - (1) Flat Demand Rate
    - (2) Wright Demand Rate
    - (3) Hopkinson Demand Rate
    - (4) Three Part, or Three Charge Rate
- III. The Electric Bill
  - A. Texas Power and Light Company
  - B. Texas Power and Light Rate Schedule
- IV. Gas Meters and Gas Rates
  - A. Gas Meter
  - B. Gas Rates
    - (1) Straight Line Rate
    - (2) Step Rate
    - (3) Block Rate
    - (4) Block Rate with Small Initial Block which Constitutes Minimum Monthly Bill.
    - (5) Service Charge Rate with Straight Line Consumption Charge.
    - (6) Flat Rate
    - (7) Wright Demand Rate
    - (8) Two-Part Rate
- V. The Gas Bill
  - A. Lone Star Gas Bill
  - B. Lone Star Gas Rate Schedule

MODULE III

UNDERSTANDING UTILITY BILLS

TERMINOLOGY

Alternating current (AC)--electric current that reverses direction periodically, usually many times per second.

Armature--that part of an electric rotating machine that includes the main current-carrying winding in which the electromotive force produced by magnetic flux rotation is induced; it may be rotating or stationary.

Current--the net transfer of electric charge per unit time.

Demand rate--any method of charge for electric service which is based upon or is a function of the extent of use or size of the customer's installation or maximum demand during a given period of time.

Direct current (DC)--any combination of electric current which flows in one direction only, such as generators and batteries, in conjunction with transmission lines, resistors, and power converters, such as motors.

Gross amount--an overall total exclusive of any deductions.

Kilowatt-hour--a unit of power equal to 1000 watts; equals about 3,400 Btu.

Net amount--a total fee free from all charges or deductions.

Odometer--an instrument for measuring the distance traveled by a vehicle.

Resistor--a device designed to have a definite amount of resistance; used in circuits to limit current flow or to provide a voltage drop.

Voltage--potential difference or electromotive force measured in volts.

Watt-hour--a unit of energy used in electrical measurements, equal to the energy converted or consumed at a rate of one watt during a period of one hour.

Wattmeter--an instrument that ordinarily measures electric power in watts.

MODULE III

UNDERSTANDING UTILITY BILLS

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MODULE III

UNDERSTANDING UTILITY BILLS

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. A watt-hour meter is installed by the power company at each home.

   a. true b. false

2. A wattmeter and a watt-hour meter measure the same thing.

   a. true b. false

3. The customary watt-hour meter reads in:

   a. watt-minutes
   b. watt-hours
   c. kilowatt-hours
   d. decawatt-hours

4. The watt-hour meter is basically a special type of motor.

   a. true b. false

5. The armature of the motor of the watt-hour meter revolves at a speed that is inversely proportional to the power used.

   a. true b. false

6. There are _______ dials of the watt-hour meter that must be read.

   a. 1
   b. 2
   c. 3
   d. 4

7. The second dial of a watt-hour meter reads in units of _______.

   a. one
   b. ten
   c. one hundred
   d. one thousand

8. The fourth dial of a watt-hour meter reads in units of _______.

   a. one
   b. ten
   c. one hundred
   d. one thousand

9. The watt-hour meter we have mentioned is usually used on D-C circuits. For A-C circuit use, it is modified by adding a ______:

   a. rectifier
   b. ohm meter
   c. volt meter
   d. none of the above

10. Demand meters are used in all homes.

   a. true   b. false

11. The ______ meter indicates the periods of the day or month when the greatest demand for energy occurs:

   a. watt
   b. demand
   c. watt-hour
   d. mini

12. The term Straight Line Meter Rate indicates that the price charged per unit:

   a. varies monthly
   b. varies yearly
   c. varies weekly
   d. is constant

13. The Step Meter Rate is becoming obsolete and is not permitted by some of the State Commissions.

   a. true   b. false

14. The Block Meter Rate is complicated and difficult for customers to understand.

   a. true   b. false

15. In contrast to your electric meter, there are ______ dials on the face of your gas meter.

   a. 2
   b. 3
   c. 5
   d. 6

16. In a gas meter, the small dial that sits above the four in a row indicates that the meter is operating.

   a. true   b. false

17. The smallest amount of gas measured by most gas meters is:

   a. 1000 cubic feet
   b. 100 cubic feet
   c. 10,000 cubic feet
   d. 10 cubic feet

18. Gas rates are not set similarly to electric rates.

    a. true b. false

19. The rate code on your gas bill represents the rate in effect in all communities of the state.

    a. true b. false

20. Estimated readings are, for various reasons, sometimes used for determining your gas bill.

    a. true b. false

MODULE III

UNDERSTANDING UTILITY BILLS

ANSWERS TO PRETEST

1. a. true
2. b. false
3. c. kilowatt-hours
4. a. true
5. b. false
6. d. 4
7. b. ten
8. d. one thousand
9. a. rectifier
10. b. false
11. b. demand
12. d. is constant
13. a. true
14. b. false
15. c. 5
16. a. true
17. b. 100 cubic feet
18. b. false
19. b. false
20. a. true

MODULE III

UNDERSTANDING UTILITY BILLS

UNIT I

ELECTRIC METERS

UNIT OBJECTIVES

1. Describe how an electric wattmeter works.
2. Explain how to read a home electric meter for watt-hour electrical consumption.

MODULE III

UNDERSTANDING UTILITY BILLS

UNIT I

ELECTRIC METERS

LECTURE

ACTIVITIES

The electric meter located on the outside wall or in the basement of a home is called a wattmeter. This measures electricity used in units called kilowatt hours, abbreviated KWH.

The power in an electric circuit is equal to the product of the voltage and the current. The wattmeter consists essentially of two coils at right angles--one fixed and one moveable. The fixed coil is made of heavy wire of low resistance and is connected in series with the load. The movable coil is made of small wire and is connected in series across the voltage of a multiplier of high resistance as in Figure 1.1.

These two coils are the current (fixed coil) and voltage (movable coil). The interaction between the two fields is proportional to the product of the voltage, and the current and deflection or movement of the indicating needle is read in watts on a calibrated scale.

The wattmeter will measure the instantaneous power used in the circuit. To determine the amount of power used for a given time, an entirely different device--called a watt-hour meter--is used. This meter sums up all the powers used for an interval of time. Such a meter is installed by the power company at each home. As the watt-hour is a relatively small unit, the customary meter reads in

DIAGRAM OF A WATTMETER

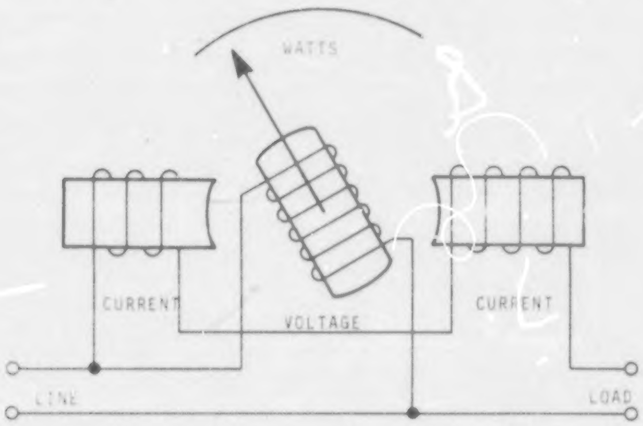

WATTS
CURRENT
VOLTAGE
CURRENT
LINE
LOAD

FIGURE 1.1

kilowatt-hours, or 1,000 watt-hours (KWH). Electric power consumed is billed at the prevailing rates per KWH.

The watt-hour meter is basically a special type of motor. Figure 1.2 shows it is designed so that the armature A of the motor revolves at a speed that is proportional to the power used.

A WATT-HOUR METER

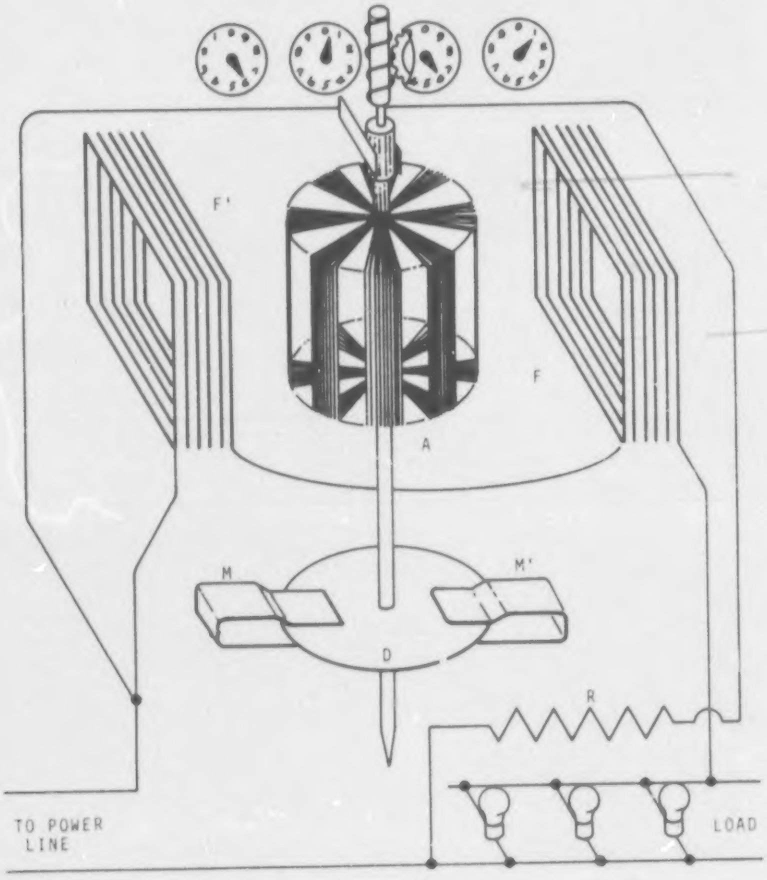


FIGURE 1.2

This is accomplished by having the field coils F and F' of the motor connected in series with the loads, thus producing a magnetic field that is proportional to the current in the load. The armature is connected in parallel with the load, through a multiplying resistor R. Therefore its magnetic field is proportional to the voltage of the load. The torque which is separately proportional to each of these fields, is therefore dependent upon their product and to the product of current and voltage, or the power. Suitable pointers, geared to turn with the armature, indicate on their respective dials the number of watt-hours or KWH used in the load. The aluminum disk D connected to the armature spindle rotates in the field of the magnetic M and M'. The induced currents thereby generated act as a brake on the armature and provide a mechanism for adjusting the rate of the rotation when the magnets are moved toward or away from the disk in servicing the device.

To read the meter, observe the four dials in Fig. 1.3. Dial A, on the extreme right, reads from 0-10 units of kilowatt hours. For each revolution of dial A, the next dial B reads one. For each revolution of dial B, dial C reads one. For each revolution of dial C, dial D reads one. Mathematically:

Dial A reads in units of one
Dial B reads in units of ten
Dial C reads in units of one hundred
Dial D reads in units of one thousand

To read the meter illustrated in Figure 1.3

Dial A points to 5
Dial B points between 5 and 6
Dial C points between 2 and 3
Dial D points between 4 and 5

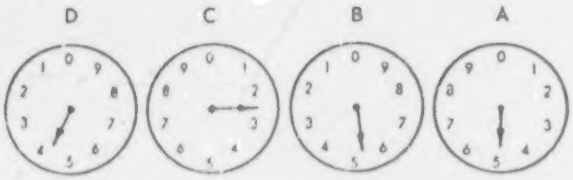


FIGURE 1.3 THE DIALS OF THE WATT-HOUR METER

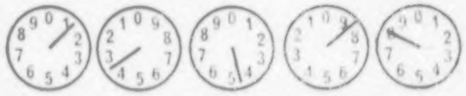
The correct reading would be 4255 KWH. Notice that when the indicating arrow is between numbers, the lowest number or the number just passed should be read, not the number the arrow is nearest. Remember, all watt-hour meters measure energy, not power.

The type of watt-hour meter indicated above is usually used on D-C circuits. For A-C circuit use, it is modified with a rectifier. A rectifier may be described as a device which permits current to flow in only one direction. When used in a meter, the rectifier allows one half-cycle of the AC current to pass, but effectively cuts off the current when it reverses itself in the second half cycle.

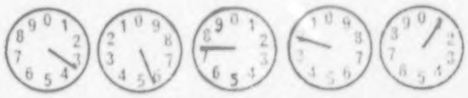
Another type of kilowatt-hour meter is the digital type watt-hour meter. This type is easier to read than the dial type because the number of units used is indicated by digital readout (Figure 1.4).

Merely read the numbers from left to right as they appear on the meter. If the number is changing, always read the lower or smaller of the two. On either the dial type or digital type meter, there may be a rating of 10X printed on the face. This means that the number of kilowatt hours shown must be multiplied by 10 to get the true reading of energy used. This is usually also indicated on the electricity bill.

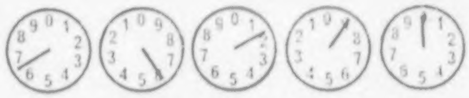
The illustration on this page shows three sets of meter dials, along with their corresponding readings. Study the sketches carefully; be sure you understand how the readings were made.



READING = 13488



READING = 35721



READING = 66190

Your electric meter is much like the odometer in your family car...it gives a total--cumulative--reading of electrical energy consumption. To find out how much energy you used during a given period of time (say one day, or one week) you must compare readings made at the beginning and end of the period.

At most residences the dial or digital wattmeter is used to measure cumulative units of energy consumed in a certain period of time. Many commercial buildings, school dormitories, and some farms and ranches have demand meters to indicate the periods of the day or month when the greatest demand for energy occurs. These peak periods are usually recorded on paper graphs or disks similar to the one in Figure 1.5. The many indication marks are referred to as ratchets. The type of meter one uses indicates the method used by the utility company in computing the periodic charge to the customer for energy spent. With a demand meter, the bill does not reflect the cumulative amount of energy used. It indicates the optimum condition of service a utility company had to reach in order to service a certain peak period. In other words, because the demand was greatest at a certain period of time, the utility company had to be big enough to furnish service at that moment, regardless of whether their continuous demand is that great.

Commercial buildings, hotels, and certain institutions have a greatly fluctuating demand. The utility company tries to identify the period of peak demand and charge the customers based on that figure.

MODULE III

UNDERSTANDING UTILITY BILLS

UNIT II

ELECTRIC RATES

UNIT OBJECTIVES

1. Discuss the various electric rate schedules available for electric companies to determine the cost of electricity to the customer.
2. Distinguish between demand rates and meter rates for electric billings.
3. Understand and compute electric costs using straight line meter rates, step meter rates, and block meter rates.
4. Understand and compute electricity costs using flat demand rates, Wright demand rates, Hopkinson demand rates, and three-part or three-charge rates.

MODULE III

UNDERSTANDING UTILITY BILLS

UNIT II

ELECTRIC RATES

LECTURE

Understanding meter readings and units of energy consumption is the first step in understanding a utility bill and the amount of money charged or the rate for energy use. The accepted forms of electric rates may be divided into two main classes: Meter Rates and Demand Rates. Each class refers to the kilowatt-hour meter or demand meter readings discussed above.

A. METER RATES

The term Meter Rate is applicable to any method of charge for electric service based solely upon quantity. The quantity is expressed in units, e.g., kilowatt-hours of electricity used.

1. Straight Line Meter Rate

The term Straight Line indicates that the price charged per unit is constant, i.e., does not vary on account of an increase or decrease in the number of units. The Straight Line Meter Rate is the simplest of all meter rates. Figure 2.1 shows this rate graphically.

2. Step Meter Rate (total bill calculated at single rate)

The term "Step" indicates that a certain specified price per unit is charged for the entire usage, the rate depending on the particular step within which the total usage falls.

ACTIVITIES

Example:
Full Schedule Form
5 cents per kilowatt-hour

Abbreviated Form Used in Rate Book
5¢ kwhr

Method of figuring bills

If the customer has a monthly usage of 100 kwh:
100 kwhr X 5¢ = $5.00

STRAIGHT LINE METER RATE

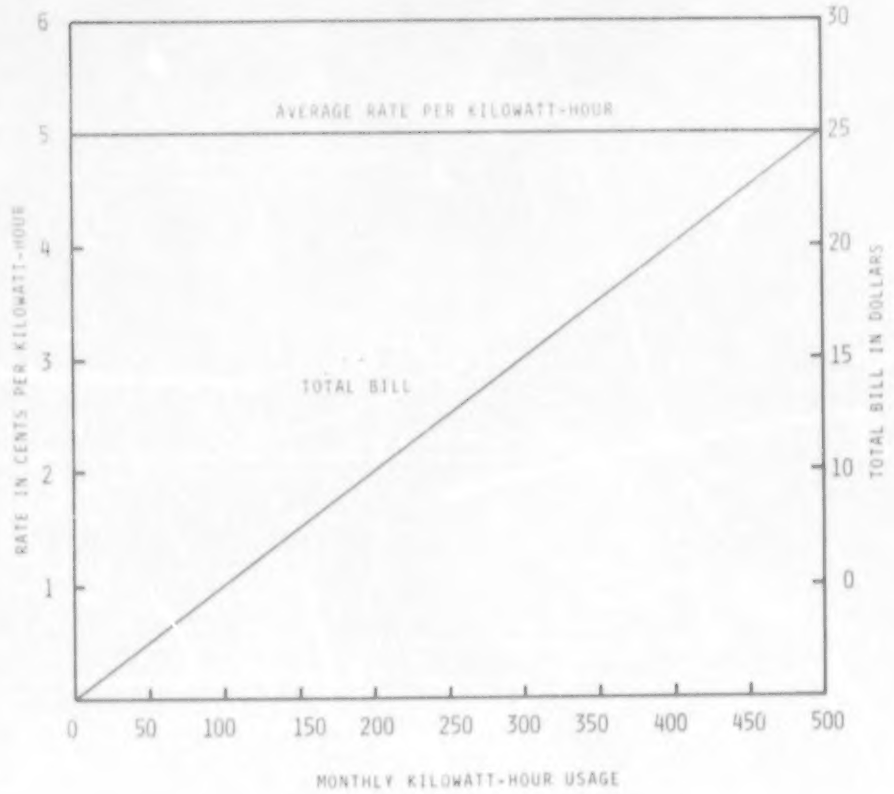


FIGURE 2.1

This type of rate is becoming obsolete and is not permitted by some of the State Commissions. Figure 2.2 shows this rate graphically:

5 cents per kilowatt-hour for from 1 to 50 kilowatt-hours used per month

4 cents per kilowatt-hour for from 51 to 100 kilowatt-hours used per month

3 cents per kilowatt-hour from 101 to 200 kilowatt-hours per month.

2 cents per kilowatt-hour for 201 or more kilowatt-hour used per month.

Abbreviated:

5¢	kwhr	1	to	50 kwhr
4¢	"	51	"	100 "
3¢	"	101	"	200 "
2¢	"	201		kwh and over

Method of Figuring Bills

Assume customer having monthly usage of 55 kwh. This usage falls within the step 51 to 100 kwh charged for at 4¢ per kwhr. This bill would be
55 kwh X 4¢ = $2.20

or, assume a customer having monthly usage of 143 kwhr. This usage falls within the step 101 to 200 kwhr charged for at 3¢ per kwhr. This bill would be
143 kwhr X 3¢ = $4.29

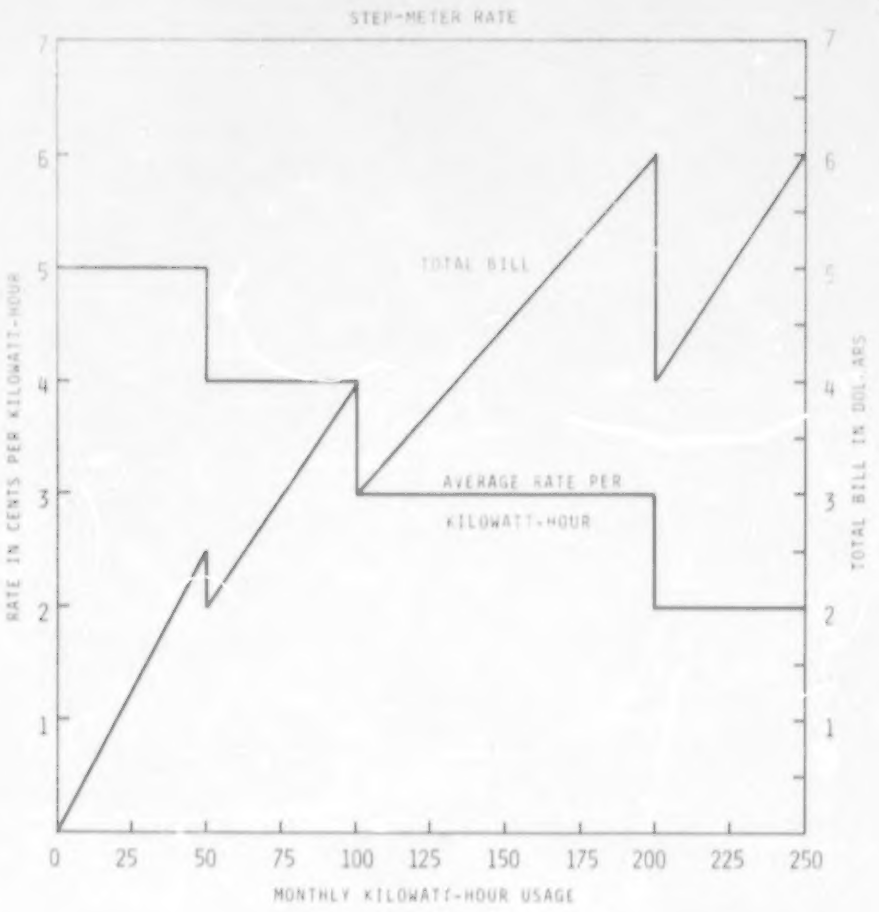


FIGURE 2.2

3. Block Meter Rate

The term Block indicates that a certain specified price per unit is charged for all or any part of a block of such units, and reduced prices per unit are charged for all or any part of succeeding blocks of such units, each such reduced price-per-unit applying only to a particular block or portion thereof.

The general simplicity of the rate and the ease with which it is understood by customers are the reasons for its use by many companies. Figure 2.3 shows this rate graphically:

Example:

10 cents per kilowatt-hour for the first 10 kilowatt-hours used per month

4 cents per kilowatt-hour for the next 25 kilowatt-hours used per month

3 cents per kilowatt-hour for the next 65 kilowatt-hours used per month

2.5 cents per kilowatt-hour for the excess over 200 kilowatt-hours used per montn.

Abbreviated:

10¢ kwh 1st10 kwhr 4¢"next25" 3¢""65" 2.5¢"excess

Method of Figuring Bills

Assume customer having monthly usage of 350 kwh

10	kwhr	X10¢	=$1.00
25	"	X 4¢	= 1.00
65	"	X 3¢	= 1.95
250	"	X2.5¢	= 6.25
			$10.20

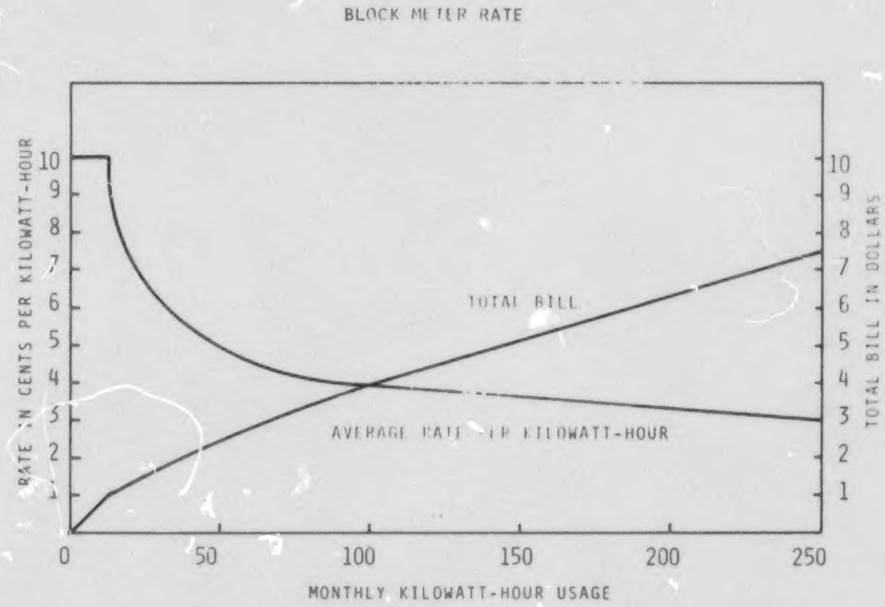


FIGURE 2.3

B. DEMAND RATES

The term Demand Rate applies to any method of charge for electric service which is based upon, or is a function of, the extent of use, or size, of the customer's installation or maximum demand, during a given period of time. The demand is generally expressed in kilowatts, kilovolt-amperes, or horsepower.

1. Flat Demand Rate

The term Flat Demand Rate applies to a charge for electric service based upon the customer's installation of energy-consuming devices. This is usually so much per watt, per kilowatt, or per horsepower per month or per year. Sometimes this type of rate is nominally so much per customer per year or per month for each of various classes of customers, but estimated demand and quantity of energy likely to be used play an important part in the determination of the class. Such a rate may be modified by the Block or Step method.

Example:

$1.00 per month for each 50 watts of installation connected or,
$25 per year for each horsepower of the connected load, or
$40 per year per kilowatt for each of the first 25 kilowatts of maximum demand, and $30 per year per kilowatt for each kilowatt in excess of 25.

Abbreviated:

$ 1.00 per 60 watts connected, or
$25.00 per yr per HP connected, or
$40.00 per yr per KW 1st 25 KW of demand
$30.00 per year KW excess

Method of Figuring Bills

Assume a customer having a connected load of 600 watts. At first rate above, the bill would be

$$\frac{600 \text{ X } \$1.00}{50} = \$12.00$$

2. Wright Demand Rate:

The term Wright Demand Rate applies to that method of charge which was the first to recognize load factor conditions and in which the demand costs were included in an initial high rate per kilowatt-hour, applicable to a certain number of hours' use of a customer's load, all excess kilowatt-hours being at a lower rate. This method of charge was first proposed by Arthur Wright in 1896. Figure 2.4 shows this rate graphically:

Example:

10 cents per kilowatt-hour for electricity used equivalent to, or less than, the first 30 hours' use per month of the maximum demand.

5 cents per kilowatt-hour for additional electricity used equivalent to, or less than, the next 30 hours' use per month of the maximum demand.

3 cents per kilowatt-hour for electricity used per month in excess of the equivalent of 60 hours' use of the maximum demand.

Abbreviated:

10¢ kwh 1st	30 hrs use of demand
5¢ kwh next	30 hrs use of demand
3¢ kwh excess	hrs use of demand

Method of Figuring Bills

Assume a customer having a connected load of 875 watts and a demand, either estimated or measured, of 700 watts, 30 hours' use of 700 watts equals 21 kwh, which is the full amount to be charged for at 10¢ and 5¢. Assume monthly usage to be 55 kwh, the bill would be

21	kwh	X	10¢ =	$2.10
21	"	X	5¢ =	1.05
13	"	X	3¢ =	.39
				$3.54

WRIGHT DEMAND RATE

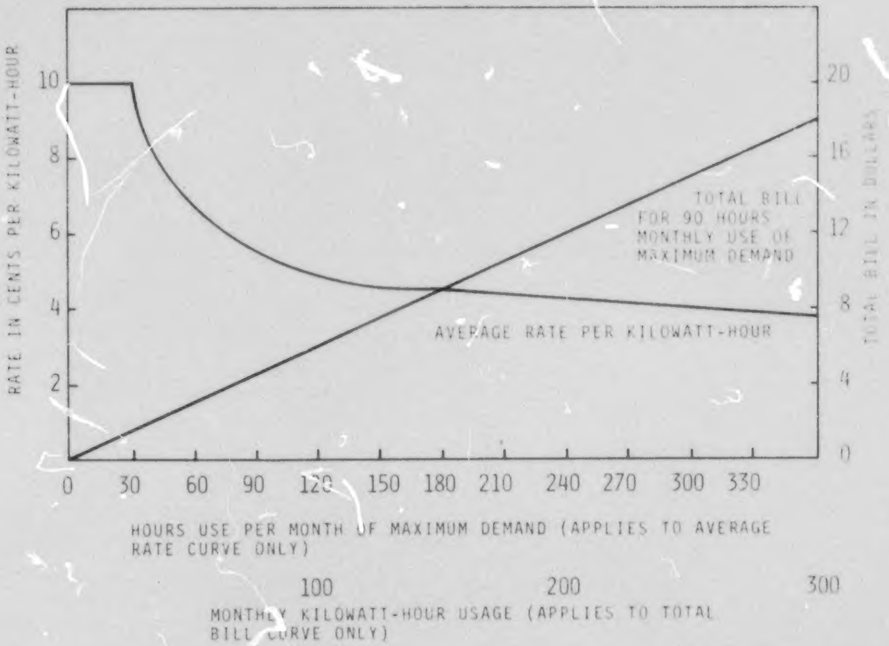


Figure 2.4

3. Hopkinson Demand Rate

The term Hopkinson Demand Rate applies to that method of charge which consists of a Demand Charge, a sum based upon the demand either estimated or measured, or the connected load, plus an Energy Charge, a sum based upon the quantity of energy used. This method of charge was proposed by Dr. John Hopkinson in 1892.

Block Hopkinson Demand Rate

Either the Demand Charge or the Energy Charge, or both, in a Hopkinson Demand Rate, may be of the block form. Figure 2.5 shows this rate graphically:

Abbreviated:

Demand charge:

Assume customer having demand of 30 KW and usage of 6,000 kwh

$1.50 per KWH 1st 25 KWH of demand
$1.25 " " excess

Energy charge:

5¢	kwh	1st 100	kwh
3¢	"	next 400	"
2¢	"	" 4,500	"
1¢	"	excess	

Method of Figuring Bills

Demand charge:

25	KW	X	$1.50	=	$37.50
5	"	X	$1.25	=	6.25
30	"				$43.75

Energy Charge:

100	kwh	X	5¢	=	5.00
400	"	X	3¢	=	12.00
4,500	"	X	2¢	=	90.00
1,000	"	X	1¢	=	10.00
6,000	"				$117.00
				Total Bill	$160.75

BLOCK HOPKINSON DEMAND RATE

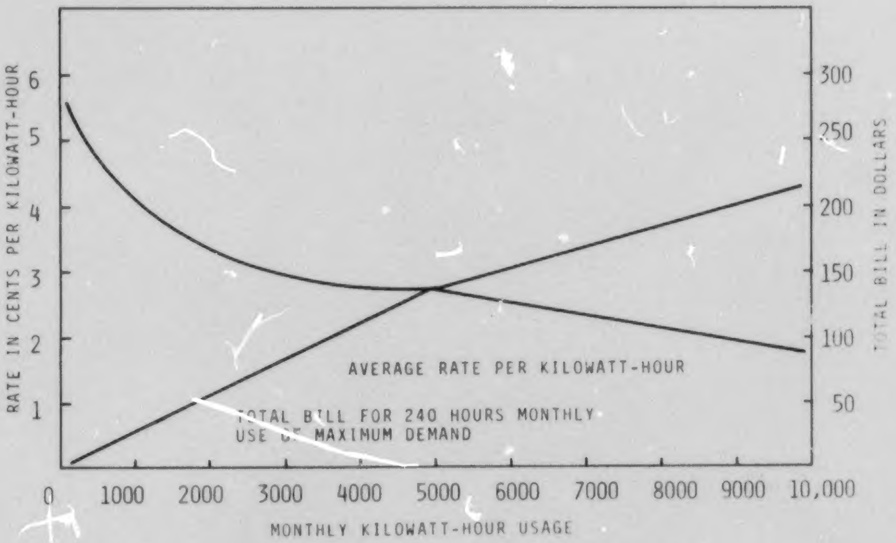


FIGURE 2.5

4. Three-Part or Three Charge Rate

Any of the foregoing types of rates may be modified by the addition of a Customer Charge. When such a charge is introduced in the Hopkinson Demand Rate, it becomes a Three-Part Rate, or Three Charge Rate, which consists of a charge per customer or per meter; plus a Demand Charge, a sum based upon the demand either estimated or measured, or the connected load; plus an Energy Charge, a sum based upon the quantity of energy used. This rate may be expressed also in either the block or the step form. This method of charge was proposed by Henry L. Doherty in 1900. The following diagram shows this rate graphically:

Example:

Customer Charge
75 cents per month per meter

Plus a Demand charge of:

$3.00 per month per kilowatt for the first 25 kilowatts of maximum demand in the month.

$2.00 per month per kilowatt for the excess of the maximum demand over 25 kilowatts.

Plus an Energy charge of:

6 cents per KWH for the first 1,000 KWH used per month.

3 cents per KWH for the excess over 1,000 KWH used per month.

Abbreviated:
Customer charge:

75 cents per month per meter

Demand Charge

$3.00 per KW 1st 25 KW of demand
$2.00 " " excess

Energy Charge:

6¢ per kwhr 1st 1,000
3¢ " " excess

Method of figuring bills assures customer having demand of 30 KWH and usage of 4,000 KWH.

Customer Charge

75 cents per month per meter
$ .75
Demand charge

25 KW X $3.00 = $75.00
5 " X 2.00 10.00
30 $85.00

Energy Charge:

1000 kwh X 6¢ $60.00
3000 " X 3¢ 90.00
4000 150.00
Total $235.75

DOHERTY OR THREE-PART CHARGE DEMAND RATE

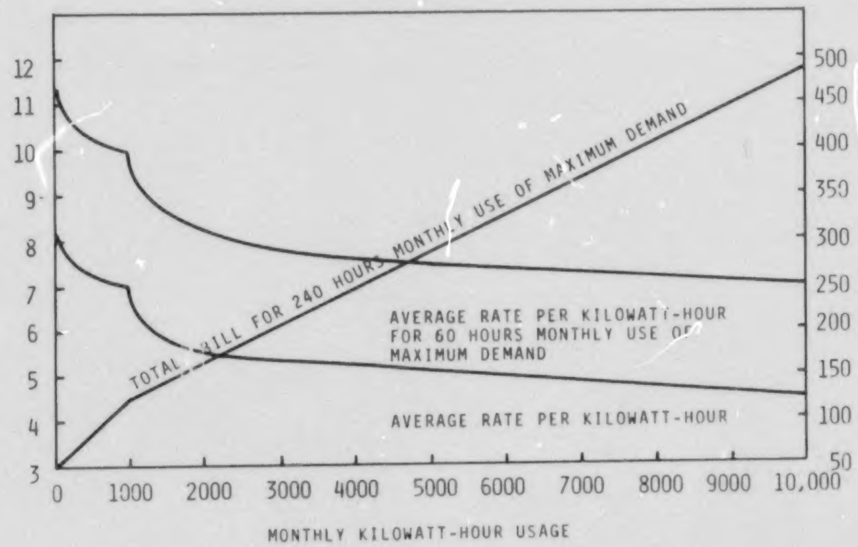


FIGURE 2.6

MODULE III

UNDERSTANDING UTILITY BILLS

UNIT III

THE ELECTRIC BILL

UNIT OBJECTIVES

1. Read and understand the household electric bill.
2. Explain the meaning of each block listed on the bill and determine what type of billing is used.
3. Determine the amount of electricity used within a month and if it is billed correctly.
4. Utilize the bill as an energy conservation management tool.
5. Be familiar with the specific electric rates set by the Texas Power and Light Company for certain cities in Texas.

MODULE III

UNDERSTANDING UTILITY BILLS

UNIT III

THE ELECTRIC BILL

LECTURE	ACTIVITIES

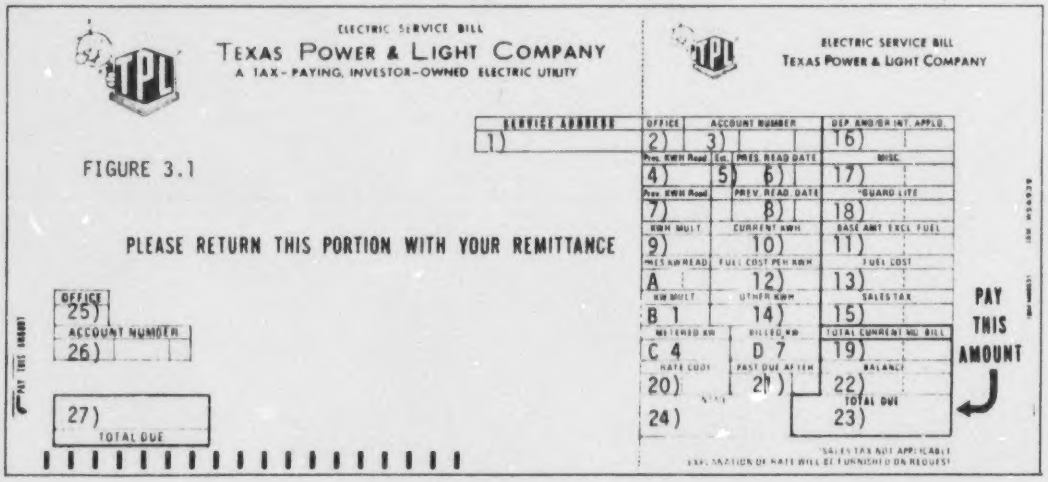
The amount of electrical energy used in a given period of time is recorded on an electrical bill directly from the meter readings. The rate for the service in the community is applied to the kilowatt-hour usage to arrive at the charge to the customer.

A. Texas Power and Light Company

In order to explain the electric bill, a bill from Texas Power and Light Company in Corsicana, Tex., will be used to illustrate the characteristics of a typical bill from an electric company. A bill for electricity issued in other parts of Texas or in other parts of the country may look different from this one, but the information listed will be similar. Below is a brief explanation of each block listed on the TP&L electric bill in Figure 3.1. This document can be a valuable instrument in energy management.

TEXAS POWER & LIGHT COMPANY

ELECTRIC BILL



ELECTRIC SERVICE BILL
TEXAS POWER & LIGHT COMPANY
A TAX-PAYING, INVESTOR-OWNED ELECTRIC UTILITY

FIGURE 3.1

PLEASE RETURN THIS PORTION WITH YOUR REMITTANCE

OFFICE 25)
ACCOUNT NUMBER 26)
27) TOTAL DUE
PAY THIS AMOUNT

ELECTRIC SERVICE BILL
TEXAS POWER & LIGHT COMPANY

SERVICE ADDRESS 1)
OFFICE 2)
ACCOUNT NUMBER 3)
Pres. KWH Read 4)
Est. 5)
PRES. READ DATE 6)
Prev. KWH Read 7)
PREV. READ DATE 8)
KWH MULT 9)
CURRENT KWH 10)
PRES KW READ A
FUEL COST PER KWH 12)
KW MULT B 1
OTHER KWH 14)
METERED KW C 4
BILLED KW D 7
RATE CODE 20)
PAST DUE AFTER 21)
24)
DEP. AND/OR INT. APPLD. 16)
MISC. 17)
*GUARD LITE 18)
BASE AMT EXCL FUEL 11)
FUEL COST 13)
SALES TAX 15)
TOTAL CURRENT MO. BILL 19)
BALANCE 22)
TOTAL DUE 23)

PAY THIS AMOUNT

*SALES TAX NOT APPLICABLE
EXPLANATION OF RATE WILL BE FURNISHED ON REQUEST

Figure 3.1

1. Service Address: This is the address of the dwelling where electricity is being used.

2. Office: This numerical code identifies the specific electric service center or community office within the service district.

3. Account Number: The individual identification number for the particular account.

4. Present Kilowatt-hour Reading: The meter reading on the date indicated in block 6.

5. Estimate Indicator: If an "E" is printed in this box the reading in Box 4 is an estimate and not an actual reading because of a barrier prohibiting the meter reader from reading the meter.

6. Present Reading Date: The date upon which the reading in box 4 was taken.

7. Previous KWH Reading: The meter reading at the end of the previous billing period.

8. Previous Reading Date: The date upon which the reading in box 7 was taken.

9. KWH Multiple: This indicates the gear ratio of the meter. If the meter has 10X printed on it, a 10 will appear in this block. On some commercial meters, the amount of electricity is so great that the meter dials must be stepped down in order not to wear out the meter. The gear ratio then must be indicated as a multiplier.

10. Current KWH: Electricity used (number of kilowatt hours) in the current billing period.

11. Base Amount Excluding Fuel Cost: Cost of the amount of electricity used, measured in KWH, before the Fuel Cost Adjustment, other amounts and taxes are added.

12. Fuel Cost per KWH: Current electricity cost adjustment rate in effect for the community. This fluctuates monthly due to fluctuating fuel costs.

13. Fuel Cost: Fuel Cost Adjustment Rate multiplied by total KWH used during the current billing period.

14. Other KWH: This block is used to indicate the amount of KWH which is not linked to the meter. If the customer has an outside guard-lite, this block will have "68" printed in it. These KWH are not metered nor figured into the Base Amount in Block 11. The "68" figure is used, however, as an additional multiplier for fuel cost adjustment in block 13.

15. Sales Tax: State and city (if applicable) sales tax amount, based on the billing amounts. At present the State of Texas does not charge a sales tax on utilities. Cities, however, have the option of charging a 1% sales tax which would appear here, if applicable.

16. Deposit and/or Interest Applied: Amount of interest accrued from customers deposit or the amount of initial service deposit credited toward the termination bill.

17. Miscellaneous: Used to list installation charges, service charges, and other costs to the customer not covered in other blocks on the bill.

18. Guard-lite: The fixed monthly fee charged for an unmetered guard-lite. Presently in Texas this is $6.70 per month. (See Unit 3B of this module for guard-lite rate schedule and service agreement).

19. Total Current Month Bill: This is the total charges for the month minus any applicable credits in block 16.

20. Rate Code: This is a numerical code which refers to the rate charged to the customer. It is not a monetary figure.

21. Past Due After: This is the date the bill is due.

22. Balance: Amount due from previous months' bill.

23. Total Due: Total amount due for electrical service for the month.

24. Name: The customer's last name and first initial.

25. Office: Same as block #2.

26. Account Number: Same as block #3.

27. Total Due: Same as block #21.

The same bill form is used for customers with rate meters and demand meters. Those customers with demand meters will have blocks A.B.C. and D completed.

A. Present Kilowatt Reading: The kilowatt supplied to the customer during the 15-minute period of maximum use during the current month, as determined by the companys' demand meter.

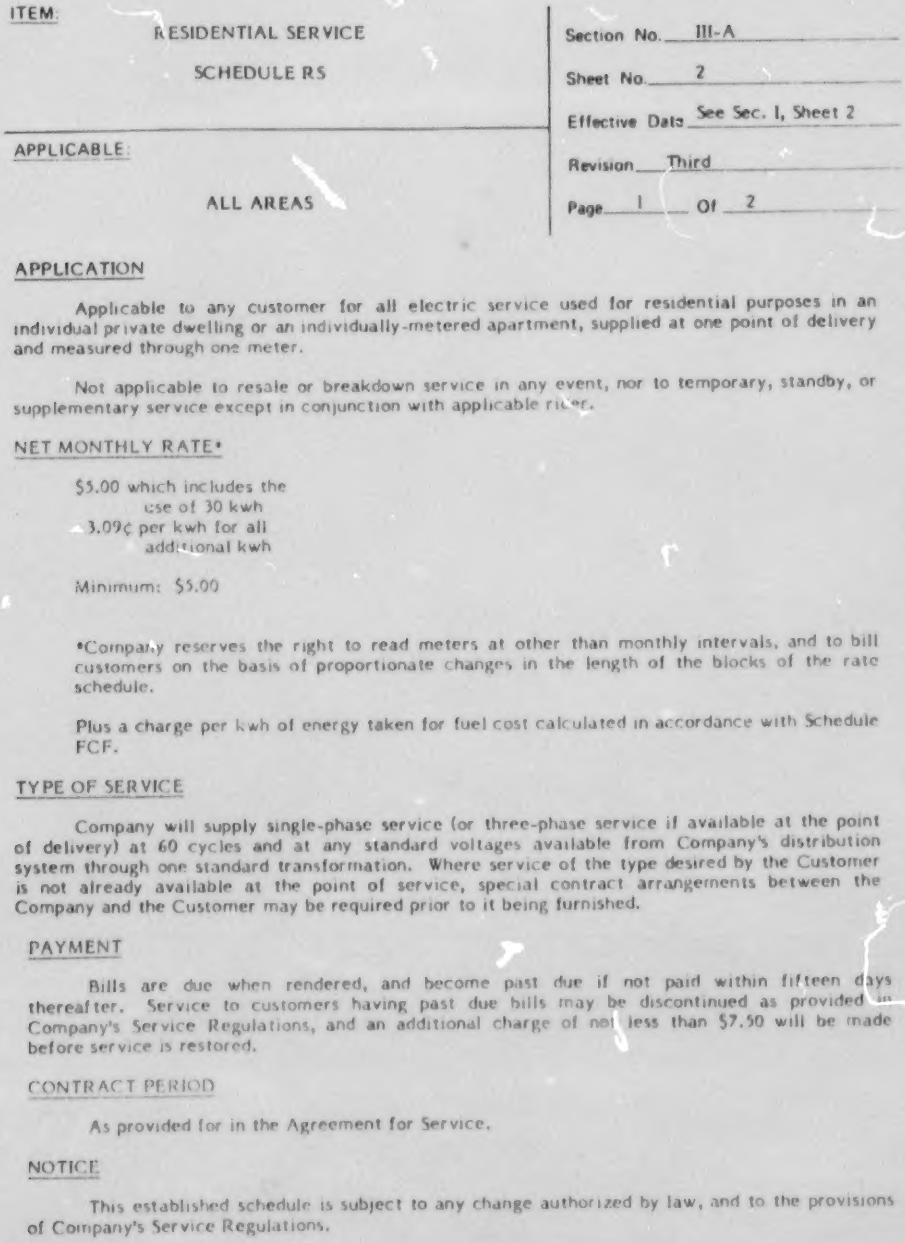
B. Kilowatt Multiplier: This indicates the gear ratio of the meter. If the meter has 10X printed on it, a 10 will appear in this block. On some commercial meters, the amount of electricity is so great that the meter must be stepped down in order not to wear out the meter. The gear ratio then must be indicated as a multiplier.

C. Metered Kilowatt: The number used as a multiplier for the peak kilowatt demand period during the month. It will not be less than 4.

D. Billed Kilowatt: This is the kilowatt demand multiplier used to determine the present billing charge. If block A is less than 4, block C will reflect a minimum number of 4 regardless of the demand for the month. Block D is not less than 70% of the maximum kw determined during the billing months of June, July, August, September, or October in the 12 months ending with the current month, but not less than 4 kw.

B. Texas Power and Light Rate Schedule.

For purposes of illustration, three rate schedules filed by the Texas Power and Light will be discussed. The first schedule is for residential service in Corsicana, Tex., serviced with rate meters. The rate code 101001 printed in block #20 of the TP&L electric bill refers to the residential service rate schedule on the following page.



ITEM:

RESIDENTIAL SERVICE

SCHEDULE RS

APPLICABLE:

ALL AREAS

Section No. III-A
Sheet No. 2
Effective Date See Sec. I, Sheet 2
Revision Third
Page 1 Of 2

APPLICATION

Applicable to any customer for all electric service used for residential purposes in an individual private dwelling or an individually-metered apartment, supplied at one point of delivery and measured through one meter.

Not applicable to resale or breakdown service in any event, nor to temporary, standby, or supplementary service except in conjunction with applicable rider.

NET MONTHLY RATE*

$5.00 which includes the use of 30 kwh
3.09¢ per kwh for all additional kwh

Minimum: $5.00

*Company reserves the right to read meters at other than monthly intervals, and to bill customers on the basis of proportionate changes in the length of the blocks of the rate schedule.

Plus a charge per kwh of energy taken for fuel cost calculated in accordance with Schedule FCF.

TYPE OF SERVICE

Company will supply single-phase service (or three-phase service if available at the point of delivery) at 60 cycles and at any standard voltages available from Company's distribution system through one standard transformation. Where service of the type desired by the Customer is not already available at the point of service, special contract arrangements between the Company and the Customer may be required prior to it being furnished.

PAYMENT

Bills are due when rendered, and become past due if not paid within fifteen days thereafter. Service to customers having past due bills may be discontinued as provided in Company's Service Regulations, and an additional charge of not less than $7.50 will be made before service is restored.

CONTRACT PERIOD

As provided for in the Agreement for Service.

NOTICE

This established schedule is subject to any change authorized by law, and to the provisions of Company's Service Regulations.

Figure 3.3 on the following page is the rate schedule and service agreement filed by TP&L governing residential use of a guardlite for Corsicana, Texas. Block #14 and #18 of the bill reflect the conditions of this rate schedule.

5-80

ITEM: OUTDOOR LIGHTING RATE SCHEDULE GL	Section No. III-B Sheet No. 9 Effective Date See Sec. I, Sheet 2
APPLICABLE: ALL AREAS	Revision Third Page 1 Of 2

APPLICATION

Applicable to any customer in areas designated by Company for unmetered lighting service supplied exclusively to one or more outdoor type 175-watt white mercury vapor lamps operating automatically every night from dusk to dawn.

NET MONTHLY RATE

$6.70 Per Lamp

Plus a charge per kwh of energy taken for fuel cost calculated in accordance with Schedule FCF.

INSTALLATION AND MAINTENANCE OF FACILITIES

Company will install, own and maintain at its own cost and expense at each lamp location, one mercury vapor luminaire complete with one 175-watt white mercury vapor lamp, lamp ballast, lamp operating equipment and an upsweep bracket on an existing Company-owned wooden pole or, at Customer's option, on an additional 30-foot wooden pole to be installed and maintained by Company at an agreed-upon location not to exceed a distance of 125 feet from Company's existing secondary distribution lines or from any other lamp location served hereunder.

Company will, at its own cost and expense, replace all burned-out lamps. All expenses covering replacement of lamps and glass refractors due to vandalism or other breakage shall be borne by Customer.

DETERMINATION OF ELECTRIC ENERGY

Electric energy supplied in the operation of this lamp will be estimated at the rate of 68 kwh per lamp per month.

PAYMENT

Bills are due when rendered, and become past due if not paid within fifteen days thereafter. Service to customers having past due bills may be discontinued as provided in Company's Service Regulations, and an additional charge of not less than $7.50 will be made before service is restored.

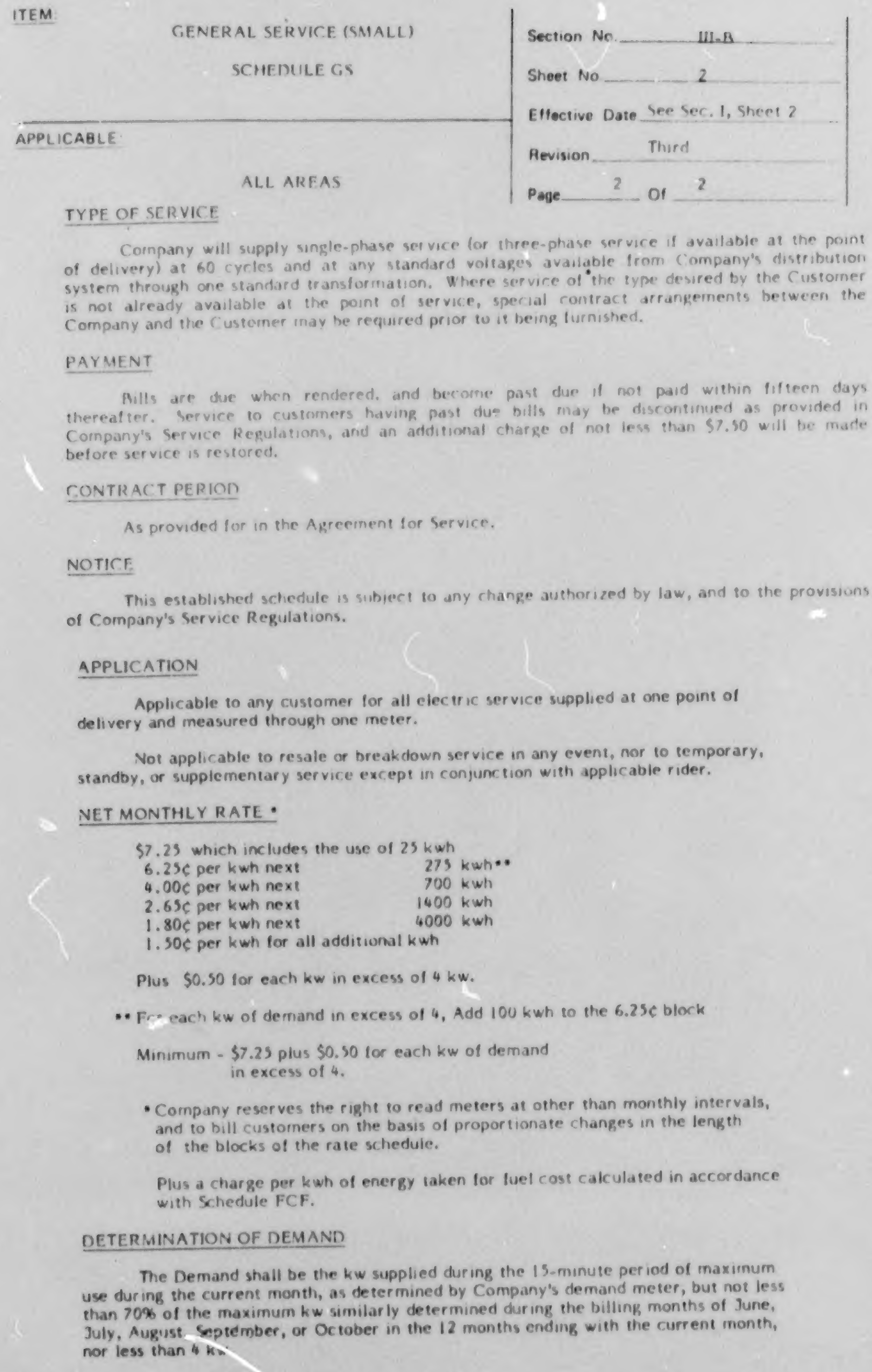
CONTRACT PERIOD

As provided for in the Agreement for Service.

NOTICE

This established schedule is subject to any change authorized by law, and to the provisions of Company's Service Regulations

Figure 3.4 is the general service rate schedule for small businesses and institutions regulated by demand meters. This schedule is on file at the Texas Power and Light company in Corsicana, Texas, and is subject to change.



ITEM

GENERAL SERVICE (SMALL)

SCHEDULE GS

Section No. III-B

Sheet No. 2

Effective Date See Sec. I, Sheet 2

Revision Third

Page 2 Of 2

APPLICABLE

ALL AREAS

TYPE OF SERVICE

Company will supply single-phase service (or three-phase service if available at the point of delivery) at 60 cycles and at any standard voltages available from Company's distribution system through one standard transformation. Where service of the type desired by the Customer is not already available at the point of service, special contract arrangements between the Company and the Customer may be required prior to it being furnished.

PAYMENT

Bills are due when rendered, and become past due if not paid within fifteen days thereafter. Service to customers having past due bills may be discontinued as provided in Company's Service Regulations, and an additional charge of not less than $7.50 will be made before service is restored.

CONTRACT PERIOD

As provided for in the Agreement for Service.

NOTICE

This established schedule is subject to any change authorized by law, and to the provisions of Company's Service Regulations.

APPLICATION

Applicable to any customer for all electric service supplied at one point of delivery and measured through one meter.

Not applicable to resale or breakdown service in any event, nor to temporary, standby, or supplementary service except in conjunction with applicable rider.

NET MONTHLY RATE *

$7.25 which includes the use of 25 kwh

6.25¢ per kwh next	275 kwh**
4.00¢ per kwh next	700 kwh
2.65¢ per kwh next	1400 kwh
1.80¢ per kwh next	4000 kwh
1.50¢ per kwh for all additional kwh	

Plus $0.50 for each kw in excess of 4 kw.

** For each kw of demand in excess of 4, Add 100 kwh to the 6.25¢ block

Minimum - $7.25 plus $0.50 for each kw of demand
in excess of 4.

* Company reserves the right to read meters at other than monthly intervals, and to bill customers on the basis of proportionate changes in the length of the blocks of the rate schedule.

Plus a charge per kwh of energy taken for fuel cost calculated in accordance with Schedule FCF.

DETERMINATION OF DEMAND

The Demand shall be the kw supplied during the 15-minute period of maximum use during the current month, as determined by Company's demand meter, but not less than 70% of the maximum kw similarly determined during the billing months of June, July, August, September, or October in the 12 months ending with the current month, nor less than 4 kw.

MODULE III

UNDERSTANDING UTILITY BILLS

UNIT IV

GAS METERS AND GAS RATES

UNIT OBJECTIVES

1. Understand how a gas meter works.
2. Read a gas meter.
3. Understand the various types of gas rates available to gas companies.
4. Compute gas costs using any of the eight types of rate schedules discussed.

MODULE III

UNDERSTANDING UTILITY BILLS

UNIT IV

GAS METERS AND GAS RATES

LECTURE

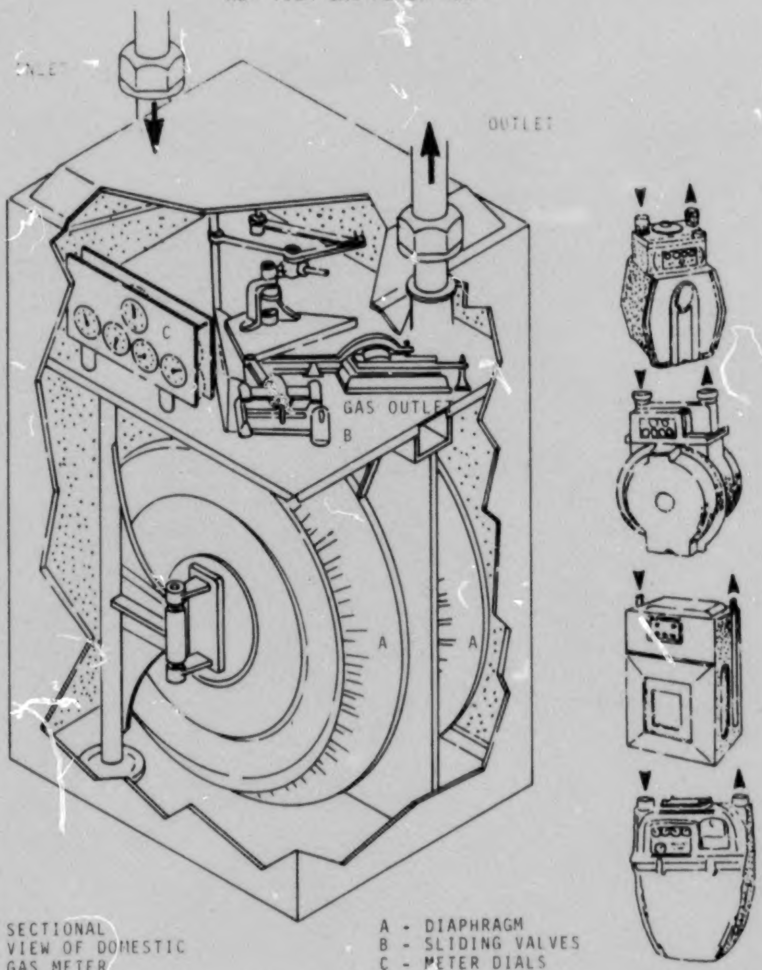
ACTIVITIES

A. Gas Meter

Natural gas is delivered to the home through underground lines. A gas meter is installed between the source and the dwelling and measures the volume of natural gas used in cubic feet (CCF). It is a finely tuned instrument calibrated for accuracy. Therefore, the amount of gas used as indicated on the meter or the gas bill is exactly the amount which passed from the main gas supply to the appliances in the home.

The meter itself is relatively simple in design (Figure 4.1). There are four chambers which fill and empty with as alternately. When the gas is turned on at the appliance the pressure drops slightly in the gas "outlet" line which runs from the meter to the appliance. The pressure in the "inlet" line going into the meter from the supply remains high. This causes an unbalanced pressure in the meter which pushes on a movable diaphragm (bellows A) and makes it expand like [illegible] accordian. Gas flows.

HOW YOUR GAS METER WORKS


INLET
OUTLET
C
GAS OUTLET
B
A
A

SECTIONAL
VIEW OF DOMESTIC
GAS METER

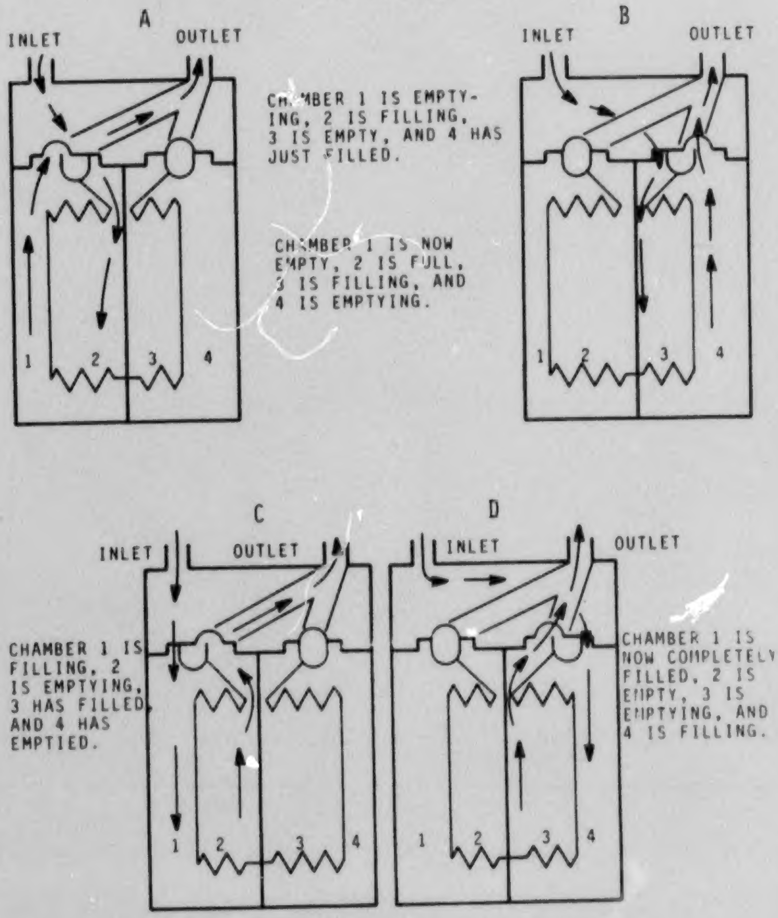
A - DIAPHRAGM
B - SLIDING VALVES
C - METER DIALS

FIGURE 4.1

The flow of gas into and out of the four separate chambers in the meter is controlled by sliding valves B so that the gas output is smooth and steady. Each chamber is filled with the same volume of gas every time. (figure 4.2 explains in detail how the sliding values control the gas flow.)

The meter dial C on the face counts the number of times the chamber is filled and emptied. Thus, the volume of gas that passes through the meter is recorded. As long as house appliances are using gas in the house, there is an unbalanced pressure in the meter, and the meter operates.

HERE'S HOW SLIDING VALVES CONTROL THE GAS FLOW



CHAMBER 1 IS EMPTYING, 2 IS FILLING, 3 IS EMPTY, AND 4 HAS JUST FILLED.

CHAMBER 1 IS NOW EMPTY, 2 IS FULL, 3 IS FILLING, AND 4 IS EMPTYING.

CHAMBER 1 IS FILLING, 2 IS EMPTYING, 3 HAS FILLED, AND 4 HAS EMPTIED.

CHAMBER 1 IS NOW COMPLETELY FILLED, 2 IS EMPTY, 3 IS EMPTYING, AND 4 IS FILLING.

FIGURE 4.2

There are five dials on the meter face (Figure 4.3). The smallest dial which sits above the four in a row is a test dial and indicates the meter is operating and gas is flowing. To read the amount of gas used the remaining four dials are read.

HOW TO READ YOUR GAS METER

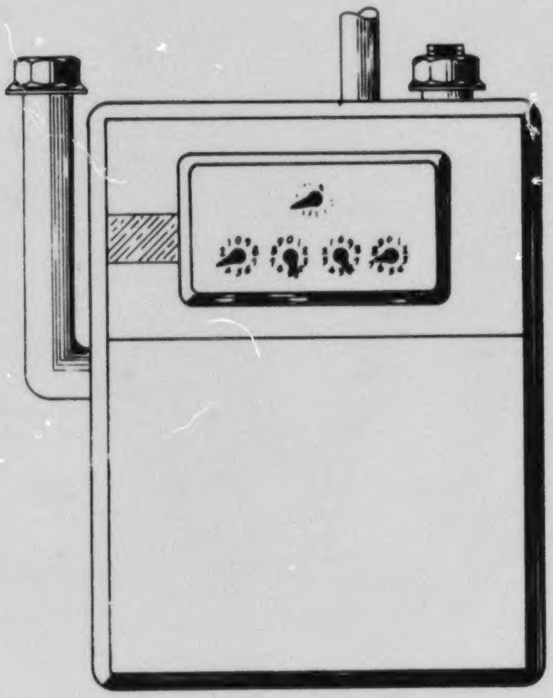


FIGURE 4.3

The dials are organized much the same way as the dials on an electric meter. Note that the smallest quantity of gas measured by most meters is 100 cubic feet (CCF). The markings on the rightmost dial A represents 100 cubic- feet; thus, the rightmost needle goes around once for every 1000 cubic-feet of gas consumed. Some of the dials rotate clockwise and some rotate counterclockwise. Since the gas meter measures a cumulative total, the four dials must be read together.

On Figure 4.3, start with the dial at the left and read the number the hand has just passed. When a hand is between numbers, always read the smaller number. The reading for the meter pictured in Figure 4.3 is 3457. Therefore the amount of gas used is 3457 Hundred Cubic Feet or 3457 CCF.

Dial A measures gas in 1,000's CCF

Dial B measures gas in 10,000's CCF

Dial C measures gas in 100,000's CCF

Dial D measures gas in 1,000,000 CCF

B. Gas Rates:

Gas rates are set similarly to electric rates. The unit of use, or hundred cubic feet (CCF), read on the meter is the indicator upon which the rate is set and the bill is issued. There are several ways of figuring a gas utility rate.

1. Straight Line Rate

Under this type of rate the price of gas per thousand cubic feet is constant, regardless of consumption.

Example: Rate - $1.50 per M (for all gas used)

2. Step Rate

Under this type of rate a specified price per MCF is paid for the entire amount of gas consumed during a given month, and the rate charged depends upon the "step" in which the total consumption falls.

Example:

Monthly Consumption Cu. ft.	Enter Consumption Billed Per M at
Under 5,000	$1.50
5,000-10,000	1.25
Over 10,000	1.00

Straight Line Rate

Problem:

Assume monthly consumption of 5,000 cubic feet.
Bill = 5,000 cu.ft. @ $2.50 per M = $7.50.

Step Rate

Problem:

Assume monthly consumption of 2,000 cubic feet.
Bill = 2,000 cu.ft. @ $1.50 per M = $3.00.

Assume monthly consumption of 8,000 cubic feet.
Bill = 8,000 cu.ft. @ $1.25 per M = $10.00.

3. Block Rate

Under this rate a constant price per MCF is charged for all gas consumed in the first "block" and a lower price per MCF is charged for all gas consumed in succeeding blocks.

Example:

Cu. Ft.	Per M
First 2,000	$1.40
Next 3,000	1.20
Next 5,000	1.00
All additional	.90

4. Block Rate with Small Initial Block which Constitutes Minimum Monthly Bill

This is a common type of rate, and is best illustrated by the following example:

First 500 cu.ft. or less cu. ft.	$1.25
	Per M
Next 1,500	1.05
Next 3,000	.90

For the above rate the minimum monthly bill is $1.25, which entitles customer to use 500 cu.ft. of gas. If monthly consumption is less than 500 cu. ft. the charge is still $1.25.

5. Service Charge Rate with Straight Line Consumption Charge

Under this type of rate, the total bill is obtained by adding the service charge to the charge for gas consumed. The consumption charge per MCF used is constant, but the average price of gas per MCF decreases as consumption increases due to spreading of the service charge over a larger consumption.

Block Rate

Problem:

Assume monthly consumption of 16,000 cu.ft.
Bill is computed as follows:
First 2,000 cu.ft. @$1.40 per M $2.80
Next 3,000 cu.ft. @ $1.20 per M 3.60
Remain-6,000 cu.ft. @ $1.00 per M 5.00
$16.80 Total Bill
Average price of gas per MCF 1.05

Block Rate and Small Initial Block which constitutes minimum monthly bill.

Problem:

Assume a monthly consumption of 12,000 cubic feet.

Bill is computed as follows:

First 500 cu.ft. $1.25
Next 1.500 cu.ft.
@$1.20per M 1.80
Next3,000 cu.ft.
@1.05per M 3.15
Remaining 7,000 cu.ft.
@.90per M 6.30
Total bill $12.50

Average price of gas per MCF $1.04

Problem

Assume monthly consumption of 5,000 cu.ft.
Bill is computed as follows:

Service charge $1.00
Consumption charge-
5,000 cu.ft. @ $.90 per M 4.50
Total bill $5.50
Average price of gas per MCF1.10

6. Flat Rate

Under this type of rate, there is a flat monthly charge depending upon some factor, such as the capacity or hourly demand of gas burning equipment, installed on the customer's premises. This type of rate is sometimes used for gas refrigeration or water heating.

Example:

For all gas used in operating a water heater with a demand of 7 cu.ft. per hour, a flat charge of $2.00 per month. For all gas used in operating a gas refrigerator with a demand of 2 cu. ft. per hour, a flat charge of $1.30 per month.

7. Wright Demand Rate

This type of rate takes in account the customer's load factor--the ratio of the average hourly consumption to the maximum hourly consumption (or the maximum hourly demand) of the customer's installation. As the customer's consumption increases without an increase in maximum demand, the load factor increases and the cost of gas per MCF decreases.

Example:

Hours of demand	Per C
First 20	$.13
Next 30	.11
All additional	.09

Example:

Service Charge
$1.00 per month
.90 per M

Note: Many rates of the service charge type have a block or other type of consumption charge, instead of a straight line consumption charge.

Problem

For a customer with a maximum demand of 80 cu.ft. and a monthly consumption of 7,000 cu. ft. bill is computed as follows:

First 20X80=1,600 cu.ft.@$.13 per C	$2.08
Next 30X80=2,400 cu.ft.@$.11 per C	2.54
Remainder 3,000 cu.ft.@$.09 per C	2.70
Total bill	$7.32
Average price of gas per MCF	$1.05

8. Two-Part Rate

This type of rate consists of two parts---a demand charge, and a commodity charge

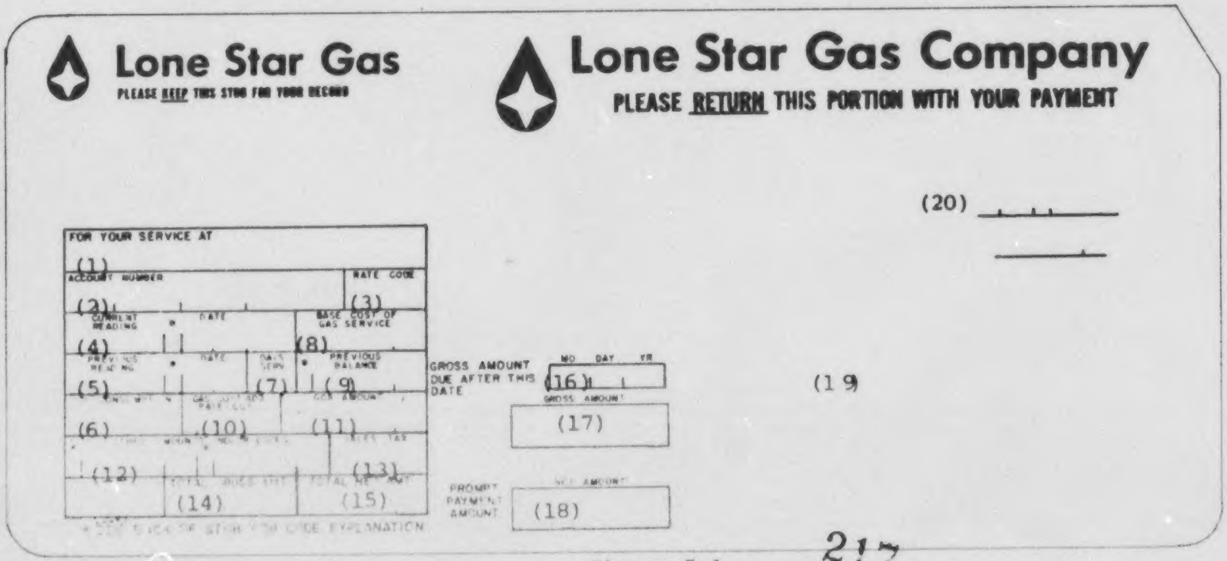
The demand charge is based on the maximum demand of the customer's installation. The commodity charge is based on the amount of gas consumed during the month.

The customer's bill is the sum of the demand and commodity charges.

There are many forms for the demand and commodity charges in this type of rate.

The demand charge may be:

(a) A flat amount per month.
(b) A constant amount per unit of demand regardless of the total demand.
(c) A block type in which the charge per unit of demand is reduced as the demand increases.
(d) Various other forms.



Lone Star Gas
PLEASE KEEP THIS STUB FOR YOUR RECORD

Lone Star Gas Company
PLEASE RETURN THIS PORTION WITH YOUR PAYMENT

(20)

FOR YOUR SERVICE AT (1)
ACCOUNT NUMBER (2)
RATE CODE (3)
CURRENT READING (4)
DATE
BASE COST OF GAS SERVICE (8)
PREVIOUS READING (5)
DATE
DAYS SERV (7)
PREVIOUS BALANCE (9)
(6)
(10)
GAS AMOUNT (11)
(12)
SALES TAX (13)
TOTAL GROSS AMT (14)
TOTAL NET AMT (15)
* SEE BACK OF STUB FOR CODE EXPLANATION

GROSS AMOUNT DUE AFTER THIS DATE
MO DAY YR
(16)
GROSS AMOUNT (17)
PROMPT PAYMENT AMOUNT
NET AMOUNT (18)

(19)

Figure 5.1

The common charge may be:

(1) Straight line type in which the charge per MCF consumed in constant.
(2) Block type in which the charge per MCF decreases as the consumption increases.
(3) Wright demand type in which the charge per MCF decreases as the customer's load factor increases.
(4) Various other forms.

The demand charge may be based on:

(1) The maximum rate of use of gas for a given interval. The inteval may be one hour, 24 hours, or one month. The maximum demand may be measured or estimated.

(2) The capacity (manufacturer's rating) of gas burning equipment in the customer's installation.

(3) In two-part house heating rates, the demand charge is usually based on one of the following: (a) the amount of cast iron radiation surface required (or its equivalent). (b) the capacity of gas burning equipment. (c) the cubical content, exposed surface and window area of the building to be heated (the heat loss from the building and hence the maximum gas demand is roughly proportional to these items).

Example:

Demand Charge Per month (Based on maximum 1-hour demand)

Cu.Ft.	Per C
First 100	$10.00
Next 200	8.00
All additional	6.00

Commodity Charge

Cu.Ft.	Per C
First 50,000	$.08
Next 100,000	.07
All additional	.06

Problem

Assume that the customer's maximum hourly demand is 700 cu.ft. and that the customer uses 400,000 cu.ft. of gas per month. Bill is computed as follows:

Demand Charge

First 100 cu.ft.of demand @$10. Per C $10.00
Next 200 cu.ft.of demand @$ 8. Per C 16.00
Remaining 400 cu.ft.of demand @ 6.00 per C 24.00
Total Demand Charge $50.00

Commodity Charge

First 50,000 cu.ft.@ $.08 Per C $40.00
Next 100,000 cu.ft.@ $.07 Per C 70.00
Remaining 250,000 cu.ft. @ $.06 Per C 150.00
Total Commodity charge $260.00
Total bill $50.00+$260.00=$310.

Average price of gas per MCF $.78

9. Three-Part Rate

This type of rate consists of three parts--a *customer* charge, *demand* charge, and *commodity* charge.

The customer charge is usually a flat charge per month or per year (payable in equal monthly installments). The demand and commodity charges are of the same type as given under *Two-Part Rates*. The customer's bill is the sum of the three charges.

Example:

Customer Charge-$1.00 per month
Demand charge
First 200 cu.ft. of demand
$.05 per cu.ft.
All additional cu.ft. of demand
$.03 per cu.ft.
Commodity Charge
First 25,000 cu.ft.
$.95 per M
All additional $.85 per M

Assume the customer's maximum one hour demand to be 250 cubic feet and monthly gas consumption to be 100,000 cubic feet.

Bill is computed as follows:

Customer Charge $1.00

Demand Charge

Demand Charge
First 200 cu.ft. @$.05
per cu. ft. $10.00
Remaining 50 cu.ft. @ .03
per cu.ft. $ 1.50
Total demand charge $11.50

Commodity Charge

First 25,000 cu.ft.
@ $.95per M = $23.75
Remaining 75,000 cu.ft.
@ $.85 Per M = $63.75
Total commodity
charge $87.50

Total bill after discount
$1.00 + $11.50 + $87.50
=$100.00
Average price of gas per MCF
=$1.00

MODULE III

UNDERSTANDING UTILITY BILLS

UNIT V

THE GAS BILL

UNIT OBJECTIVES

1. Read a gas bill and appreciate the information it gives.
2. Be familiar with the Lone Star Gas Company rate schedule for various cities in Texas.

MODULE III

UNDERSTANDING UTILITY BILLS

UNIT V

THE GAS BILL

LECTURE	ACTIVITIES

I. The Gas Bill

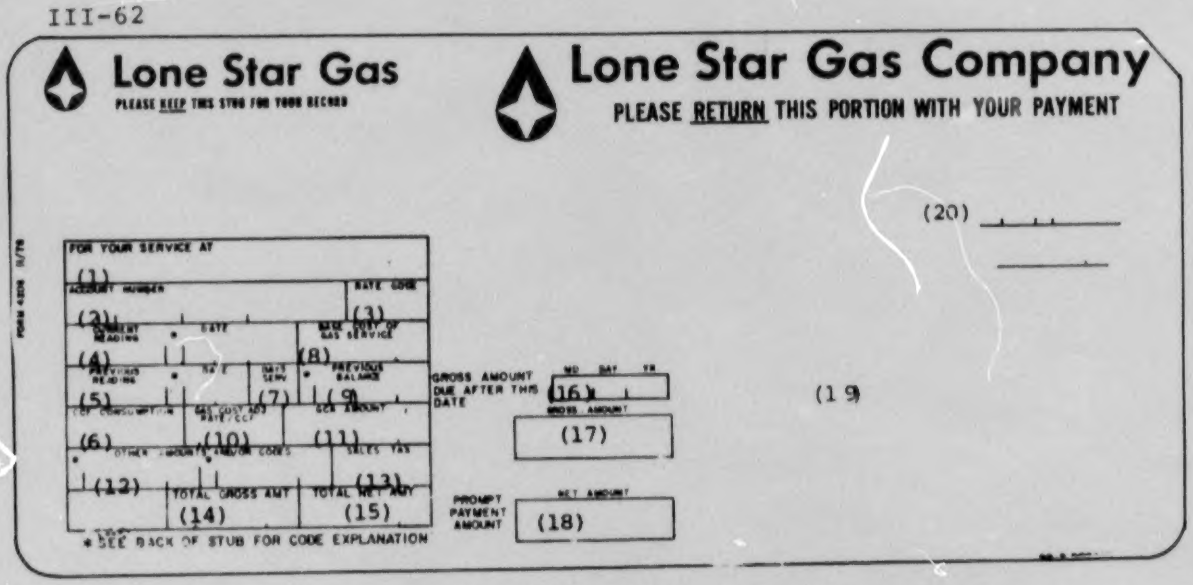
The amount of gas used in a given period of time is recorded on a gas bill directly from the meter reading. The rate for the service in the community is applied to the hundred cubic feet (CCF) of usage to arrive at the charge to the customer.

A. Lone Star Gas Bill

In order to explain the gas bill, a Lone Star Gas Company bill in Corsicana, Tex., will be used to illustrate the characteristics of a typical gas bill. A bill for gas used in other parts of Texas or in other parts of the country may look different from this one, but the information listed will be similar.

On the following page is a brief explanation of each block listed on the Lone Star gas bill at Figure 5.1, which must be understoond in order for the bill to be a viable instrument for energy management.

Explain each of the blocks on the gas bill in figure 5.1. Specifically write the formula used for arriving at the Gross Amount Due shown on the bill.



Lone Star Gas

PLEASE KEEP THIS STUB FOR YOUR RECORD

Lone Star Gas Company

PLEASE RETURN THIS PORTION WITH YOUR PAYMENT

FOR YOUR SERVICE AT (1)
ACCOUNT NUMBER (2)
RATE CODE (3)
CURRENT READING * DATE (4)
BASE COST OF GAS SERVICE (8)
PREVIOUS READING * DATE (5)
DAYS SERV (7)
* PREVIOUS BALANCE (9)
CCF CONSUMPTION (6)
GAS COST ADJ RATE/CCF (10)
GCA AMOUNT (11)
* OTHER AMOUNTS AND/OR CODES (12)
SALES TAX (13)
TOTAL GROSS AMT (14)
TOTAL NET AMT (15)
* SEE BACK OF STUB FOR CODE EXPLANATION
GROSS AMOUNT DUE AFTER THIS DATE MO DAY YR (16)
GROSS AMOUNT (17)
PROMPT PAYMENT AMOUNT NET AMOUNT (18)
(19)
(20)

Figure 5.1

(21) CODE EXPLANATION

A. APPLIANCE SERVICE
B. CONNECT CHARGE
C. CREDIT
D. DEPOSIT AND/OR INTEREST APPLIED
E. ESTIMATED READING
F. FINAL BILL
G. OTHER CHARGES
H. GAS AIR CONDITIONER
M. METER EXCHANGE

BILLING EXPLANATION

CCF = HUNDREDS OF CUBIC FEET

BILLING INCLUDES AN ADJUSTMENT FOR THE INCREASE OR DECREASE IN THE PRICE THE COMPANY MUST PAY FOR NATURAL GAS PURCHASED FOR OUR CUSTOMERS. THE ADJUSTMENT FOR CHANGES IN GAS COST HAS BEEN APPROVED BY THE REGULATORY AUTHORITIES HAVING JURISDICTION IN YOUR SERVICE AREA.

(Back of card)

1. For Your Service At: This is the service address of the dwelling where gas is being used.

2. Account Number: The individual identification number for the particular account.

3. Rate Code: This three-digit code represents the rate in effect in the community.

4. Current Reading and Date: The meter reading on the date indicated. If an "E" is printed in the box below the asterisk, the reading was an estimate and not an actual reading, due to a locked gate, dog, obstruction of meter, or other barriers prohibiting the meter reader from reading the meter.

5. Previous Reading and Date: The meter reading at the end of the previous billing period. Subtract this figure from Current Reading and Date to determine how much gas (number of CCF) used. (See note in #4 for a code of "E")

6. CCF Consumption: Gas used (number of CCF) in the current billing period.

7. Days Service: The number of days from Previous Date to Current Date.

8. Base Cost of Gas Service: Cost of the amount of gas used, measured in CCF, before the Gas Cost Adjustment, other amounts, and taxes are added.

9. Previous Balance: Amount unpaid from previous billing period.

10. Gas Cost Adjustment Rate/CCF: Current gas cost adjustment rate in effect for the community. One CCF=100 cubic feet of gas.

11. Gas Cost Adjustment (GCA) Amount: GCA Rate multiplied by total gas (number of CCF) used during the current billing period.

12. Other Amounts and/or Codes: Amount of special service charges due Lone Star Gas. The specific service will be preceded by a code letter from the back of the card. Code Explanation:

A. Appliance Service
B. Connect Charge
C. Credit
D. Deposit and/or interest paid on the customer's installation deposit is often credited to the bill.
G. Other Charges
M. Meter Exchange

13. Sales Tax: State and city (if applicable) sales tax amount, based on the billing amounts. At present the State of Texas does not charge a sales tax on utilities. Cities, however, have the option of charging a 1% sales tax which would appear here, if applicable.

14. Total Gross Amount: Includes Gross Cost of Gas Service, GCA, Other Amounts and Sales Tax.

15. Total Net Amount: Amount due if paid promptly. Prompt payment rates are not included in city ordiances in some communities.

16. Discount Date: Last date to pay Net Amount due before Gross Amount becomes due.

17. Gross Amount: Same as #14 above.

18. Net Amount: Same as #15 above.

19. Name and Address: Name and street address to whom bill is sent.

20. Office Identification: The numerical identification of the Lone Star Gas Company Office.

21. Code Explation: On reverse side of card is an explation of the letter codes used in various blocks on the front of the bill, where applicable.

A. Appliance Service--Applies to servicing of company owned appliances used by the customer, such as outside lights, grills, etc.

B. Connect Charge--Charge for connecting or reconnecting gas meter and service to the home.

C. Credit--amount due customer for overpayment.

D. Deposit and/or Interest Applied--amount of interest accrued from customers deposit or the amount of initial service deposit credited toward termination bill.

E. Estimated Reading--a guess of amount of gas used instead of an actual meter reading due to locked gate, dog, or other barriers prohibiting meter reader from obtaining a reading.

F. Final Bill--indication of termination of service bill.

G. Other Charges--miscellaneous code for various charges.

H. Special Air Conditioning Rate--indication of a special rate negotiated for the customer because of special air conditioning.

I. Meter Exchange--charge for replacing a broken or malfunctioning meter.

B. Lone Star Gas Rate Schedule

The rate schedule for residential and commercial use of gas in the state of Texas is regulated by the Railroad Commission. Figure 5.2 is an excerpt from the rate schedule for Corsicana, Tex., filed by the Lone Star Gas Company with the Texas Railroad Commission.

FIGURE 5.2

TYPICAL GAS RATE SCHEDULE (WINTER)
LONE STAR GAS COMPANY

RESIDENTIAL AND COMMERCIAL RATE SCHEDULE

MONTHLY RATE:

Applicable to gas consumed between the meter reading dates of October and May of the following year.

Residential:

Customer Charge	$ 3.0000
All Consumption @	$ 2.2558 Per Mcf

If the service period is less than 28 days, the customer charge is $.1071 times the number of days of service.

Commercial:

Customer Charge	$ 6.0000
All Consumption @	$ 2.2558 Per Mcf

If the service period is less than 28 days, the customer charge is $.2143 times the number of days service.

PROMPT PAYMENT PROVISION:

Bills are due and payable when rendered and must be paid within ten (10) days* from monthly billing date.

BILLING ADJUSTMENTS:

The following adjustment is applicable if letter "T" follows the rate schedule number in the index.

The amount of each monthly bill computed at the above stated rates shall be subject to the following adjustment: Plus an amount equivalent to the proportionate part of any new tax, or increased rate of tax, or governmental imposition or charge (except state, county, city, and special district ad valorem taxes and any taxes on net income) levied or assessed against the Company or on its gas business, as the result of any new or amended law, ordiance or contract, after July 1, 1978.

The following adjustment is applicable if letter "G" follows the rate schedule number in the index.

* Fifteen (15) days for environs

The amount of each monthly bill computed at the above stated rates shall be subject to the following adjustment: An estimated city gate rate less $1.8392, multiplied by a volume expansion factor (to recover increases in gas costs associated with Unaccounted For Gas up to 5% and Company Used Gas), plus a correction factor to compensate for the second previous month's over or under recovery of increases or decreases in the city gate rate, multiplied by a tax factor.

MODULE III

UNDERSTANDING UTILITY BILLS

POSTTEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. The watt-hour meter has _______ dials that must be read.

   a. 1
   b. 2
   c. 3
   d. 4

2. The armature of the meter of the watt-hour revolves at a speed that is directly proportional to the power used.

   a. true b. false

3. Actually, the watt-hour meter is just a special type of meter.

   a. true b. false

4. The usual watt-hour meter reads in kilowatt-hours.

   a. true b. false

5. A wattmeter and a watt-hour meter do not measure the same thing.

   a. true b. false

6. Every home has a watt-hour meter that is installed by the power company.

   a. true b. false

7. The demand meter indicates the periods of the day or month when the greatest demand for energy occurs.

   a. true b. false

8. Not all homes have demand meters.

   a. true b. false

9. The watt-hour meter is usually used on D-C circuits and it cannot be modified for A-C use.

   a. true b. false

10. The fourth dial of a watt-hour meter reads in units of one thousand.

    a. true b. false

11. The watt-hour meter's second dial reads in units of one.

    a. true b. false

12. There is no way that you can look at the dials of a gas meter and tell whether or not it is operating.

    a. true b. false

13. Your gas meter has _______ dials on its face.

    a. 2
    b. 3
    c. 5
    d. 6

14. The Block Meter Rate is relatively simple for customers to understand.

    a. true b. false

15. All states permit the Step Meter Rate to be used.

    a. true b. false

16. The term Straight Line Meter Rate indicates that the price charged per unit is constant.

    a. true b. false

17. Estimated readings are never used for determining your gas bill.

    a. true b. false

18. The rate code on your gas bill does not represent the rate in effect in all communities of the state.

    a. true b. false

19. Gas rates are set in a manner similar to electric rates.

    a. true b. false

20. 100 cubic feet is the smallest amount of gas that is measured by most gas meters.

    a. true b. false

MODULE III

UNDERSTANDING UTILITY BILLS

ANSWERS TO POSTTEST

1. d. 4
2. a. true
3. a. true
4. a. true
5. a. true
6. a. true
7. a. true
8. a. true
9. b. false
10. a. true
11. b. false
12. b. false
13. c. 5
14. a. true
15. b. false
16. a. true
17. b. false
18. a. true
19. a. true
20. a. true

DIAGRAM OF A WATTMETER

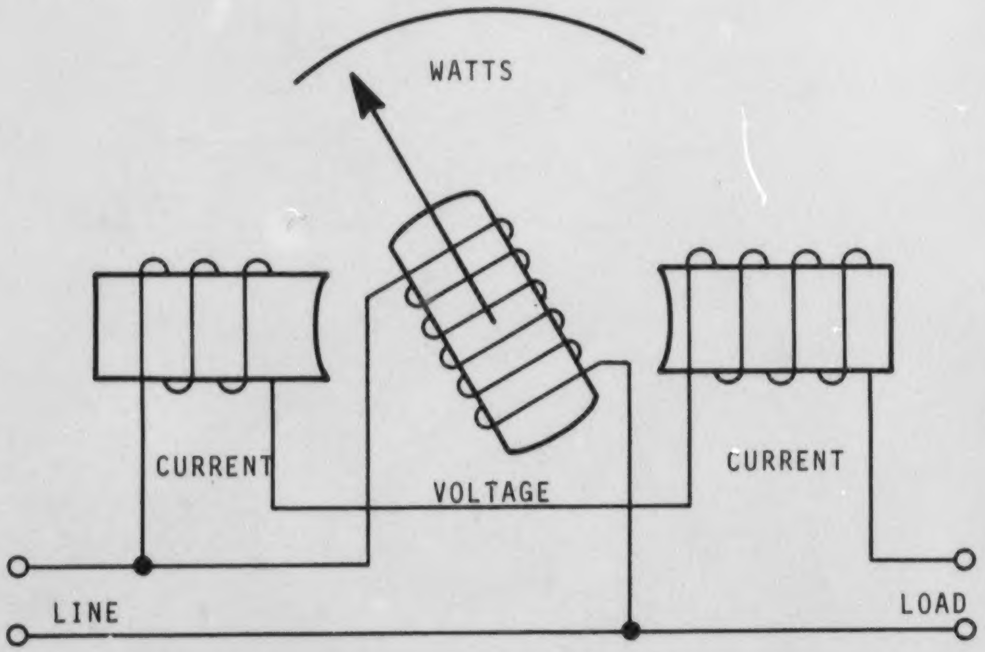

WATTS
CURRENT
VOLTAGE
CURRENT
LINE
LOAD

FIGURE 1.1

A WATT-HOUR METER

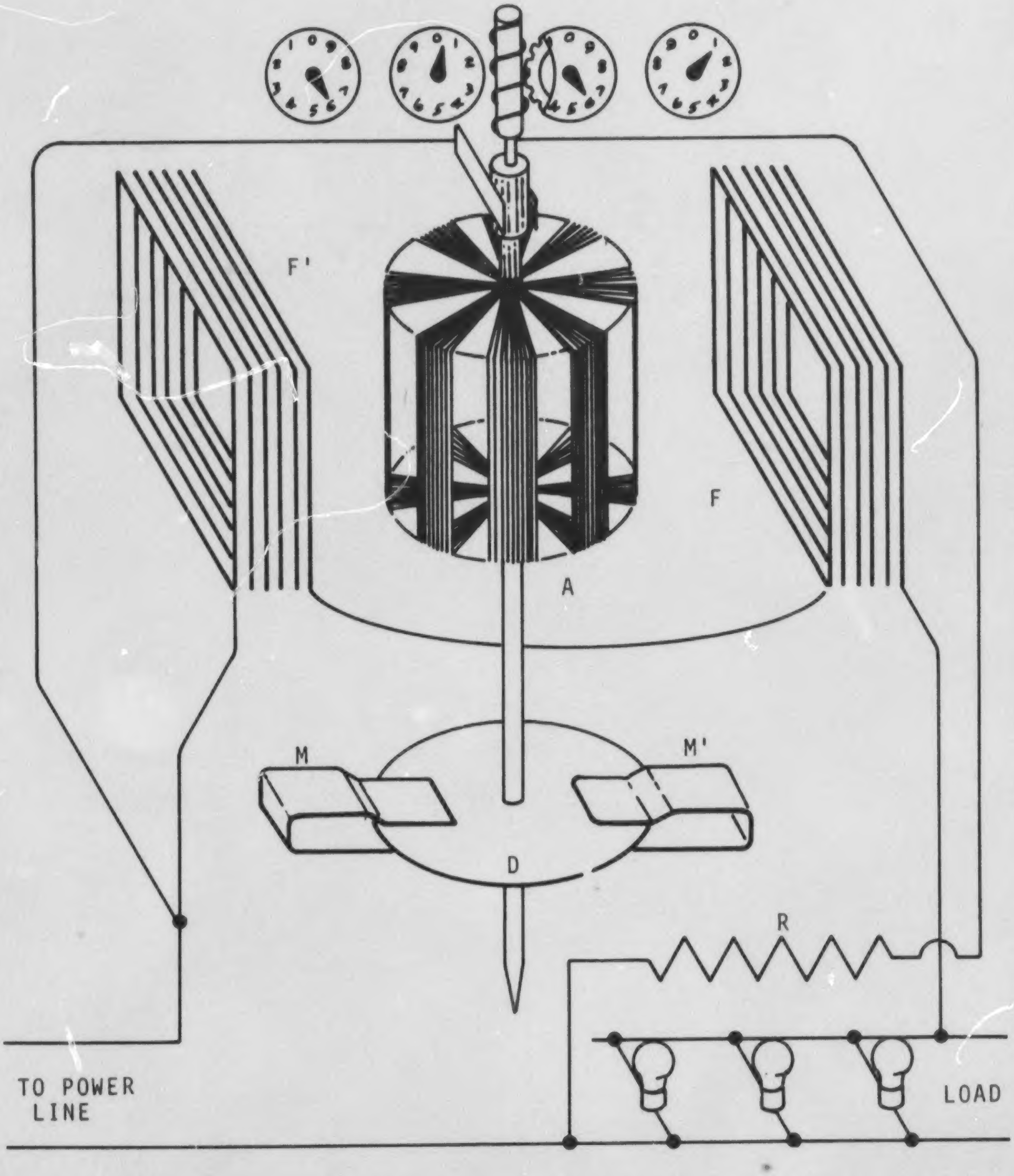

F'
F
A
M
M'
D
R
TO POWER LINE
LOAD

FIGURE 1.2

THE DIALS OF THE WATT-HOUR METER

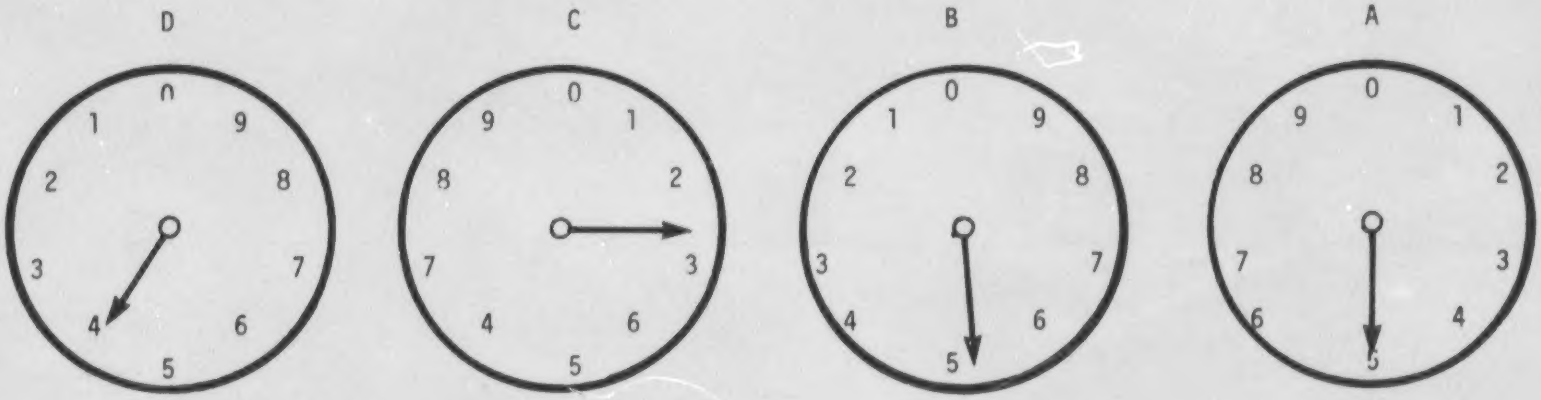

D
C
B
A
0
1
2
3
4
5
6
7
8
9

FIGURE 1.3

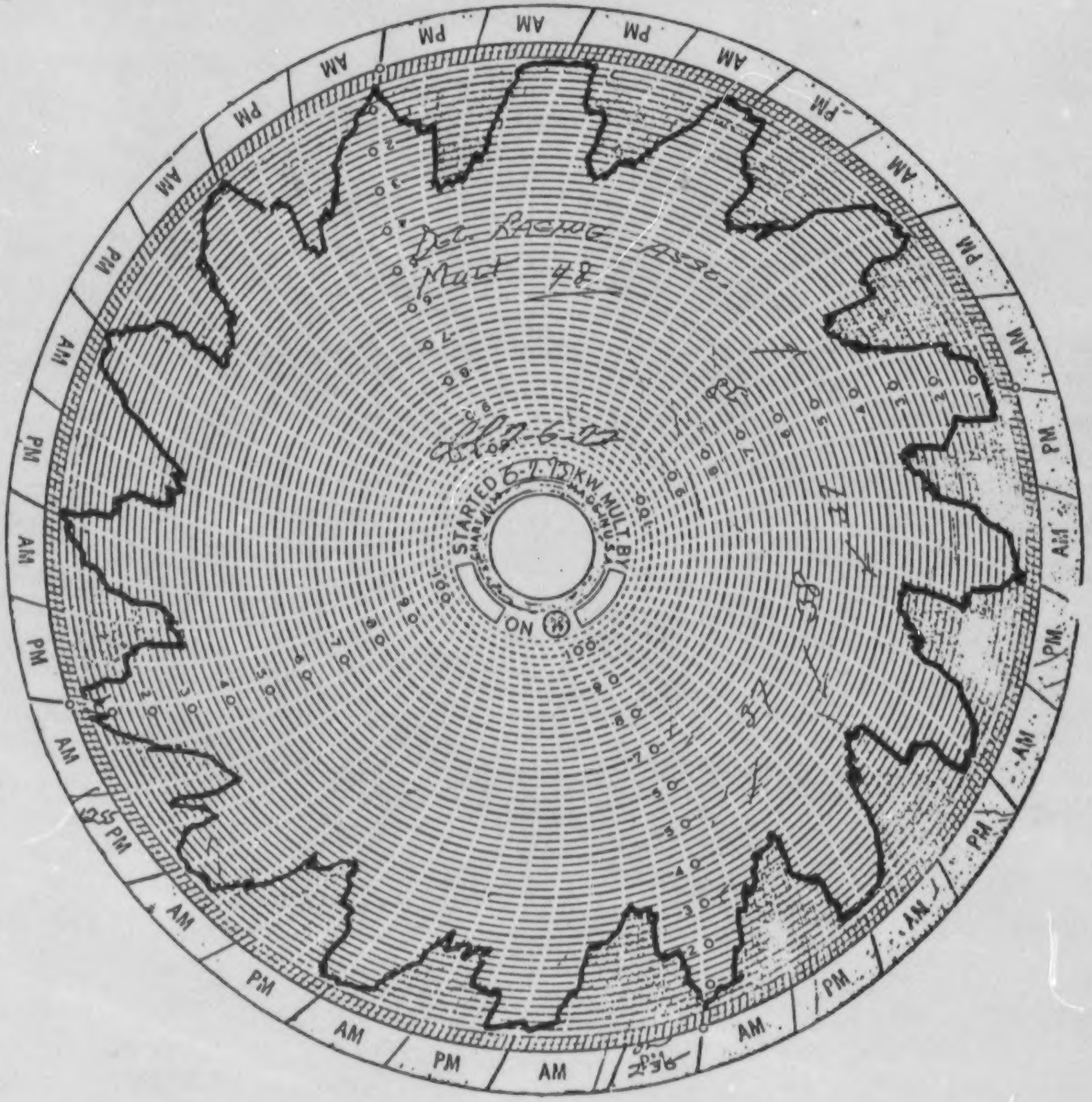


FIGURE 1.4

ELECTRIC DEMAND METER READING

STRAIGHT LINE METER RATE

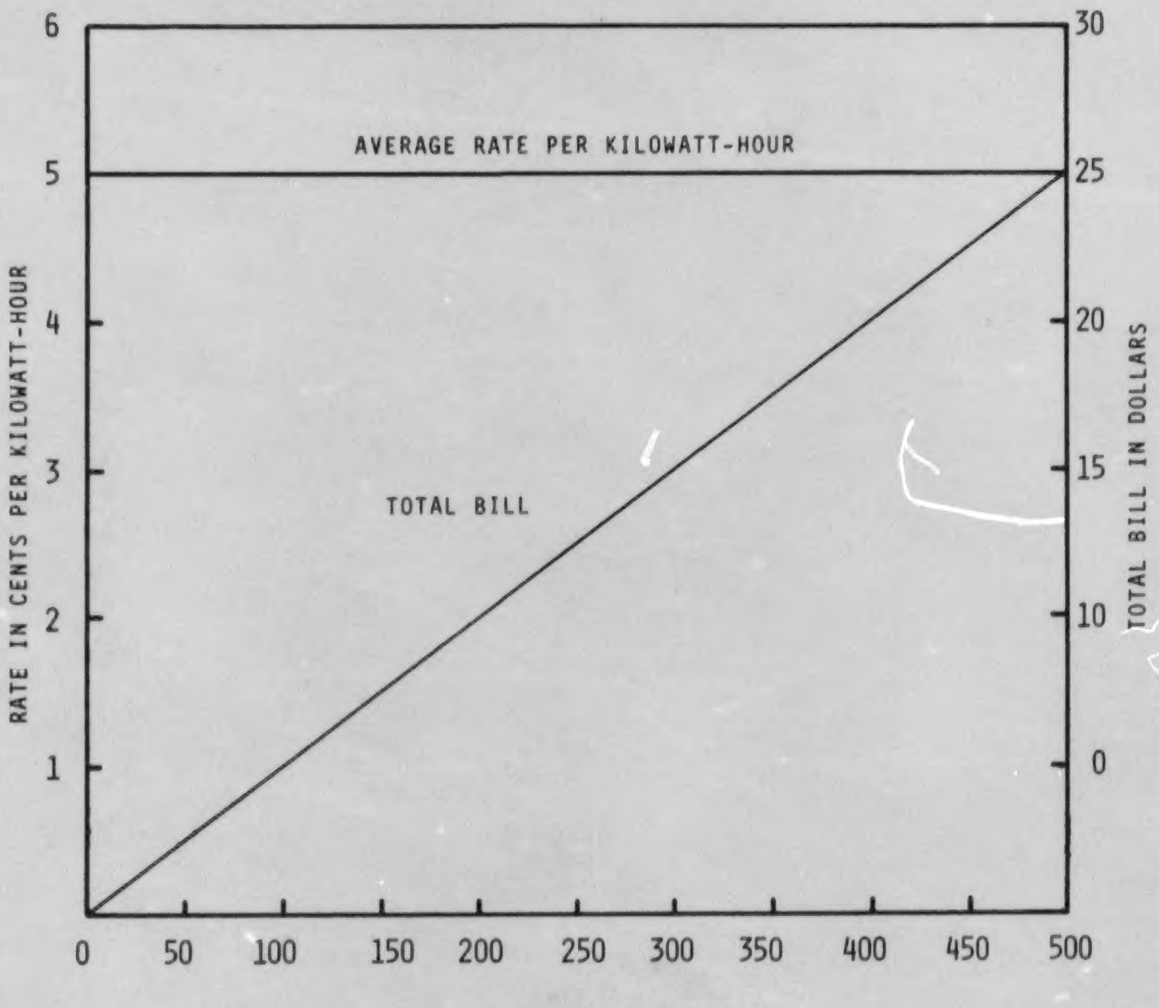


FIGURE 2.1

STEP-METER RATE

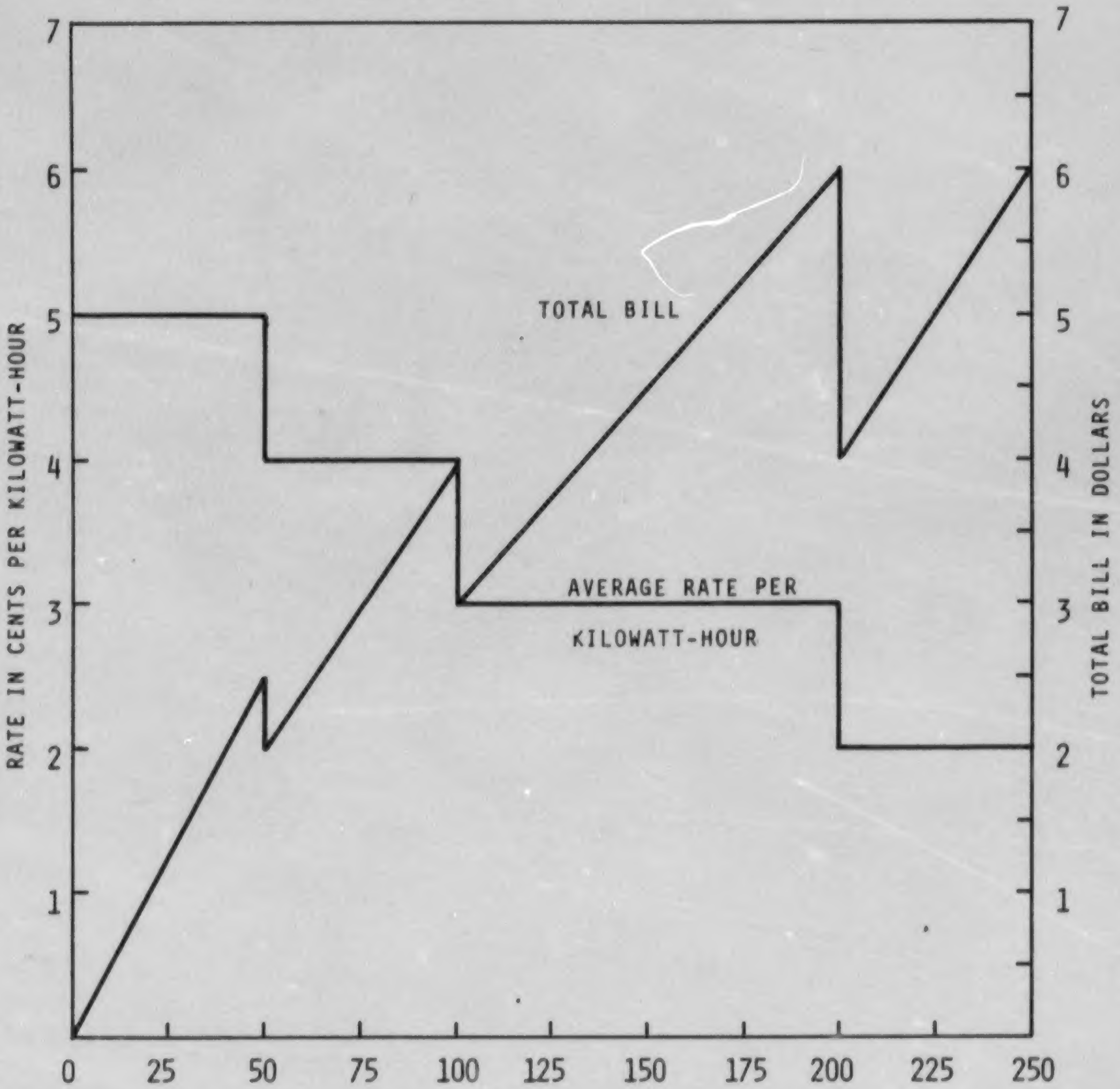


FIGURE 2.2

BLOCK METER RATE

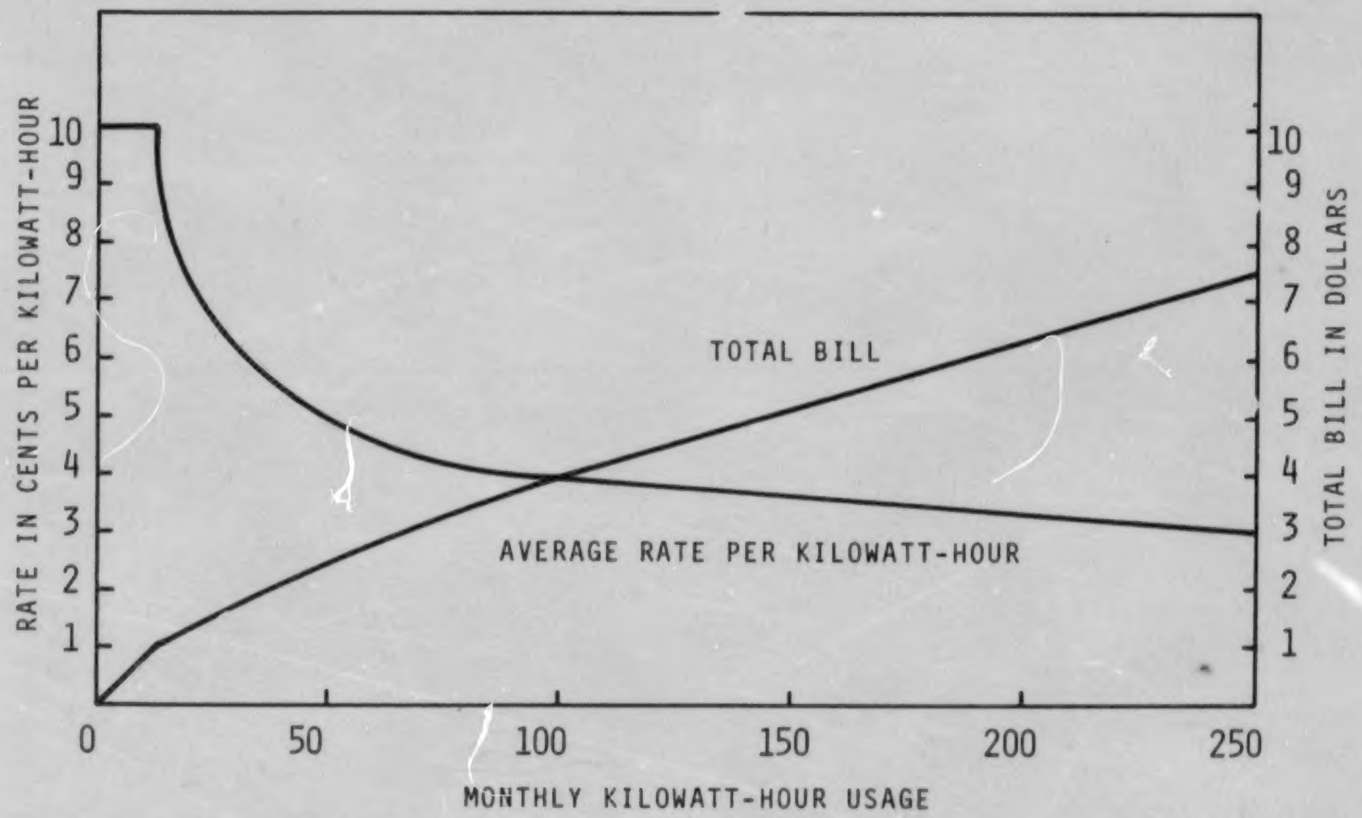


FIGURE 2.3

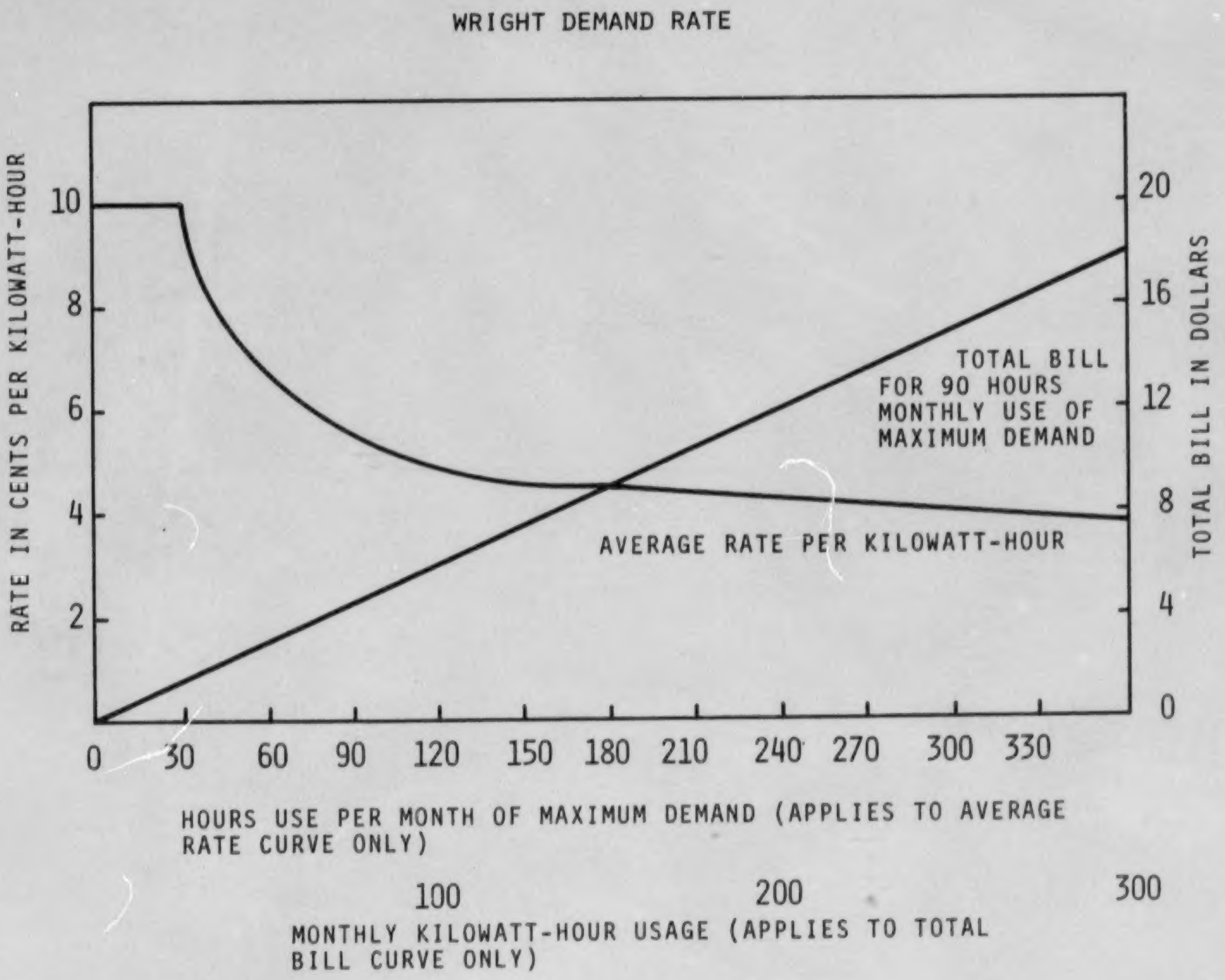

WRIGHT DEMAND RATE
RATE IN CENTS PER KILOWATT-HOUR
10
8
6
4
2
TOTAL BILL IN DOLLARS
20
16
12
8
4
0
TOTAL BILL FOR 90 HOURS MONTHLY USE OF MAXIMUM DEMAND
AVERAGE RATE PER KILOWATT-HOUR
0
30
60
90
120
150
180
210
240
270
300
330
HOURS USE PER MONTH OF MAXIMUM DEMAND (APPLIES TO AVERAGE RATE CURVE ONLY)
100
200
300
MONTHLY KILOWATT-HOUR USAGE (APPLIES TO TOTAL BILL CURVE ONLY)

FIGURE 2.4

BLOCK HOPKINSON DEMAND RATE

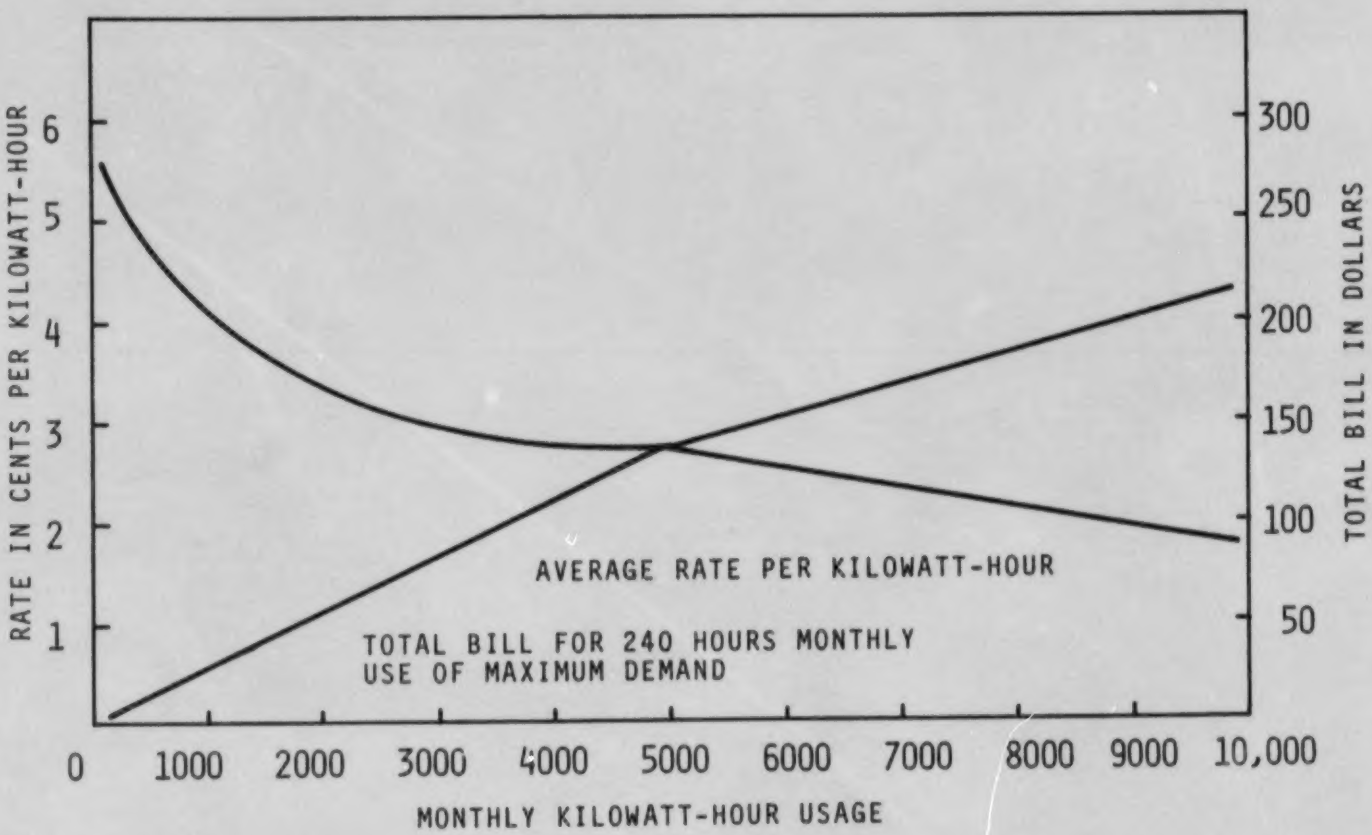


FIGURE 2.5

DOHERTY OR THREE PART CHARGE DEMAND RATE

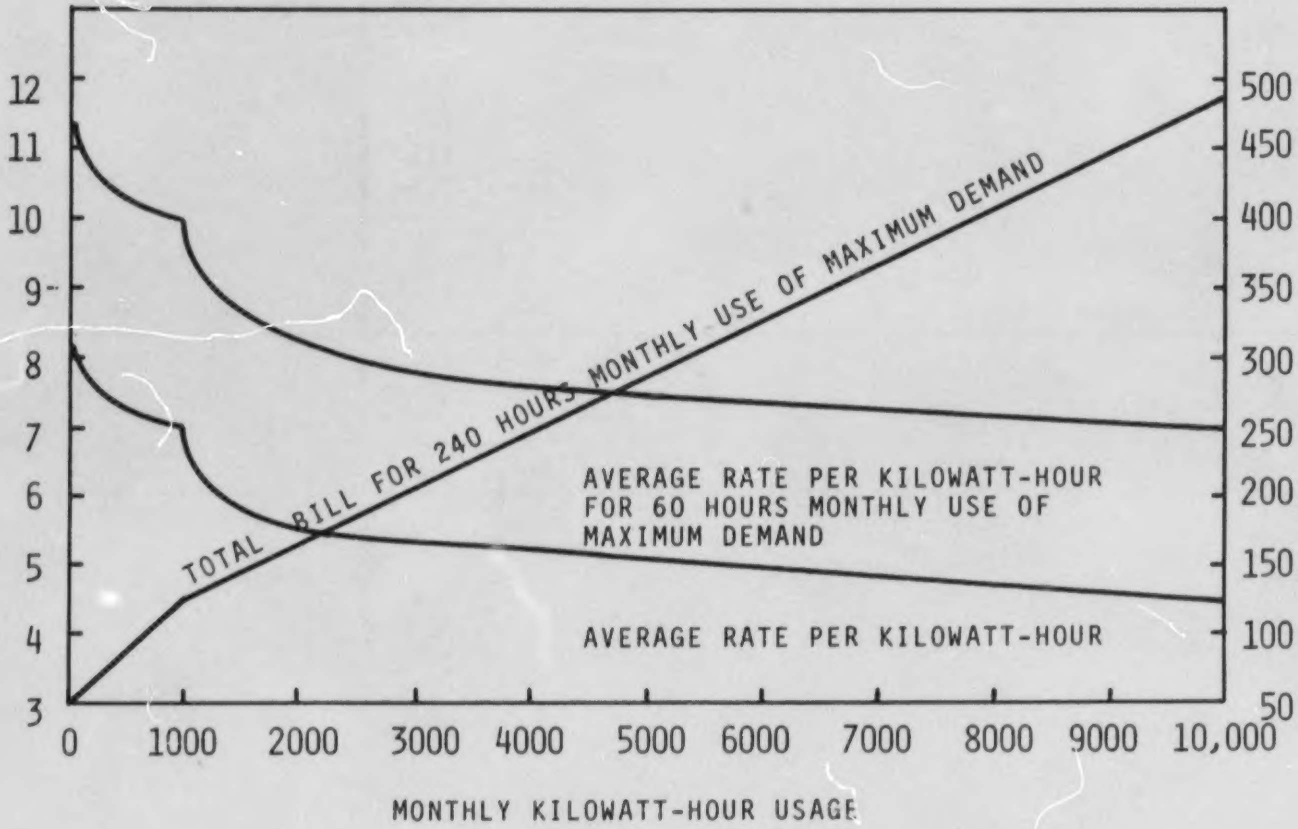


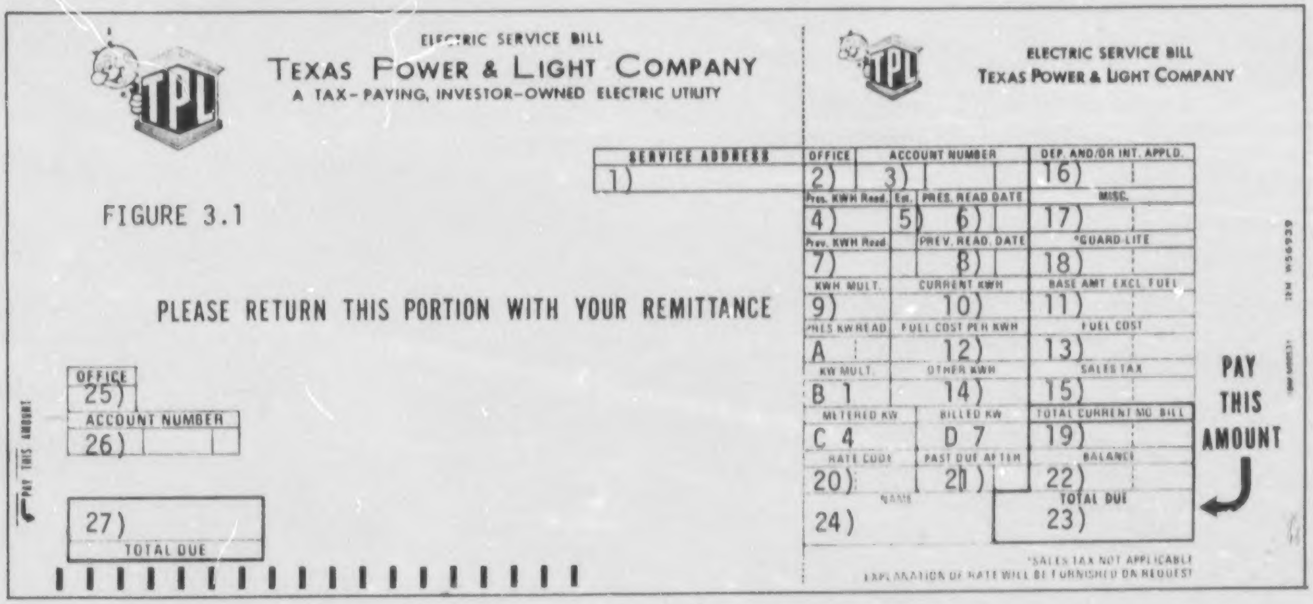
FIGURE 2.6

244

213

TEXAS POWER & LIGHT COMPANY

ELECTRIC BILL



ELECTRIC SERVICE BILL
TEXAS POWER & LIGHT COMPANY
A TAX-PAYING, INVESTOR-OWNED ELECTRIC UTILITY

FIGURE 3.1

PLEASE RETURN THIS PORTION WITH YOUR REMITTANCE

OFFICE 25)
ACCOUNT NUMBER 26)
PAY THIS AMOUNT
27)
TOTAL DUE

ELECTRIC SERVICE BILL
TEXAS POWER & LIGHT COMPANY

SERVICE ADDRESS	OFFICE	ACCOUNT NUMBER	DEP. AND/OR INT. APPLD.
1)	2)	3)	16)

Pres. KWH Read.	Est.	PRES. READ DATE	MISC.
4)	5)	6)	17)
Prev. KWH Read		PREV. READ. DATE	*GUARD LITE
7)		8)	18)
KWH MULT.	CURRENT KWH		BASE AMT. EXCL. FUEL
9)	10)		11)
PRES KW READ	FUEL COST PER KWH		FUEL COST
A	12)		13)
KW MULT.	OTHER KWH		SALES TAX
B 1	14)		15)
METERED KW	BILLED KW		TOTAL CURRENT MO. BILL
C 4	D 7		19)
RATE CODE	PAST DUE AFTER		BALANCE
20)	21)		22)
NAME			TOTAL DUE
24)			23)

PAY THIS AMOUNT

*SALES TAX NOT APPLICABLE
EXPLANATION OF RATE WILL BE FURNISHED ON REQUEST

FIGURE 3.1

5-80

ITEM: RESIDENTIAL SERVICE SCHEDULE RS	Section No. III-A Sheet No. 2 Effective Date See Sec. I, Sheet 2
APPLICABLE: ALL AREAS	Revision Third Page 1 Of 2

APPLICATION

Applicable to any customer for all electric service used for residential purposes in an individual private dwelling or an individually-metered apartment, supplied at one point of delivery and measured through one meter.

Not applicable to resale or breakdown service in any event, nor to temporary, standby, or supplementary service except in conjunction with applicable rider.

NET MONTHLY RATE*

$5.00 which includes the
use of 30 kwh
3.09¢ per kwh for all
additional kwh

Minimum: $5.00

*Company reserves the right to read meters at other than monthly intervals, and to bill customers on the basis of proportionate changes in the length of the blocks of the rate schedule.

Plus a charge per kwh of energy taken for fuel cost calculated in accordance with Schedule FCF.

TYPE OF SERVICE

Company will supply single-phase service (or three-phase service if available at the point of delivery) at 60 cycles and at any standard voltages available from Company's distribution system through one standard transformation. Where service of the type desired by the Customer is not already available at the point of service, special contract arrangements between the Company and the Customer may be required prior to it being furnished.

PAYMENT

Bills are due when rendered, and become past due if not paid within fifteen days thereafter. Service to customers having past due bills may be discontinued as provided in Company's Service Regulations, and an additional charge of not less than $7.50 will be made before service is restored.

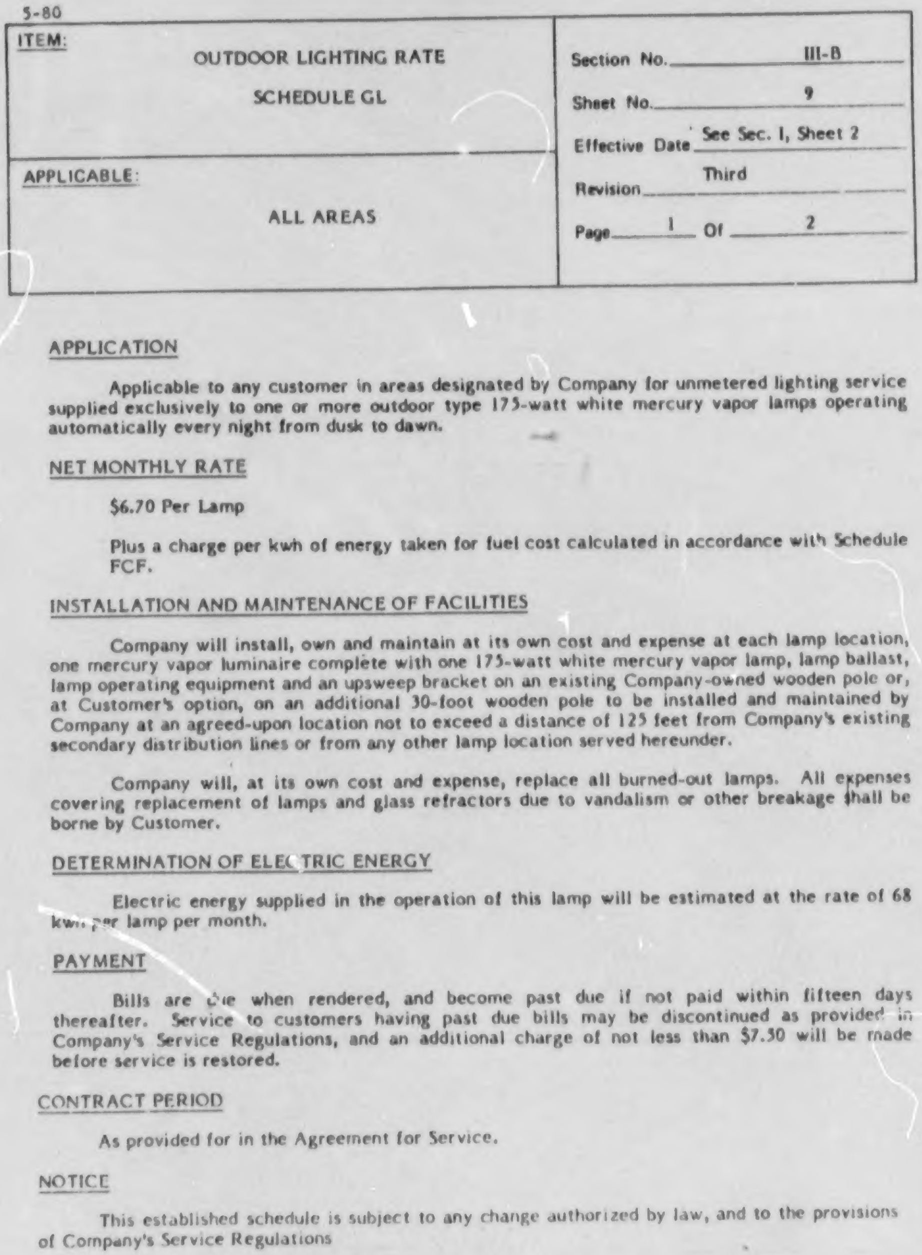
CONTRACT PERIOD

As provided for in the Agreement for Service.

NOTICE

This established schedule is subject to any change authorized by law, and to the provisions of Company's Service Regulations.

FIGURE 3.2



5-80

ITEM: OUTDOOR LIGHTING RATE SCHEDULE GL	Section No. III-B Sheet No. 9 Effective Date See Sec. I, Sheet 2
APPLICABLE: ALL AREAS	Revision Third Page 1 Of 2

APPLICATION

Applicable to any customer in areas designated by Company for unmetered lighting service supplied exclusively to one or more outdoor type 175-watt white mercury vapor lamps operating automatically every night from dusk to dawn.

NET MONTHLY RATE

$6.70 Per Lamp

Plus a charge per kwh of energy taken for fuel cost calculated in accordance with Schedule FCF.

INSTALLATION AND MAINTENANCE OF FACILITIES

Company will install, own and maintain at its own cost and expense at each lamp location, one mercury vapor luminaire complete with one 175-watt white mercury vapor lamp, lamp ballast, lamp operating equipment and an upsweep bracket on an existing Company-owned wooden pole or, at Customer's option, on an additional 30-foot wooden pole to be installed and maintained by Company at an agreed-upon location not to exceed a distance of 125 feet from Company's existing secondary distribution lines or from any other lamp location served hereunder.

Company will, at its own cost and expense, replace all burned-out lamps. All expenses covering replacement of lamps and glass refractors due to vandalism or other breakage shall be borne by Customer.

DETERMINATION OF ELECTRIC ENERGY

Electric energy supplied in the operation of this lamp will be estimated at the rate of 68 kwh per lamp per month.

PAYMENT

Bills are due when rendered, and become past due if not paid within fifteen days thereafter. Service to customers having past due bills may be discontinued as provided in Company's Service Regulations, and an additional charge of not less than $7.50 will be made before service is restored.

CONTRACT PERIOD

As provided for in the Agreement for Service.

NOTICE

This established schedule is subject to any change authorized by law, and to the provisions of Company's Service Regulations

Figure 3.3

5-80

ITEM: GENERAL SERVICE (SMALL) SCHEDULE GS	Section No. III-B Sheet No. 2 Effective Date See Sec. I, Sheet 2
APPLICABLE: ALL AREAS	Revision Third Page 2 Of 2

TYPE OF SERVICE

Company will supply single-phase service (or three phase service if available at the point of delivery) at 60 cycles and at any standard voltages available from Company's distribution system through one standard transformation. Where service of the type desired by the Customer is not already available at the point of service, special contract arrangements between the Company and the Customer may be required prior to it being furnished.

PAYMENT

Bills are due when rendered, and become past due if not paid within fifteen days thereafter. Service to customers having past due bills may be discontinued as provided in Company's Service Regulations, and an additional charge of not less than $7.50 will be made before service is restored.

CONTRACT PERIOD

As provided for in the Agreement for Service.

NOTICE

This established schedule is subject to any change authorized by law, and to the provisions of Company's Service Regulations.

APPLICATION

Applicable to any customer for all electric service supplied at one point of delivery and measured through one meter.

Not applicable to resale or breakdown service in any event, nor to temporary, standby, or supplementary service except in conjunction with applicable rider.

NET MONTHLY RATE *

$7.25 which includes the use of 25 kwh	
6.25¢ per kwh next	275 kwh**
4.00¢ per kwh next	700 kwh
2.65¢ per kwh next	1400 kwh
1.80¢ per kwh next	4000 kwh
1.50¢ per kwh for all additional kwh	

Plus $0.50 for each kw in excess of 4 kw.

** For each kw of demand in excess of 4, Add 100 kwh to the 6.25¢ block

Minimum - $7.25 plus $0.50 for each kw of demand
in excess of 4.

* Company reserves the right to read meters at other than monthly intervals, and to bill customers on the basis of proportionate changes in the length of the blocks of the rate schedule.

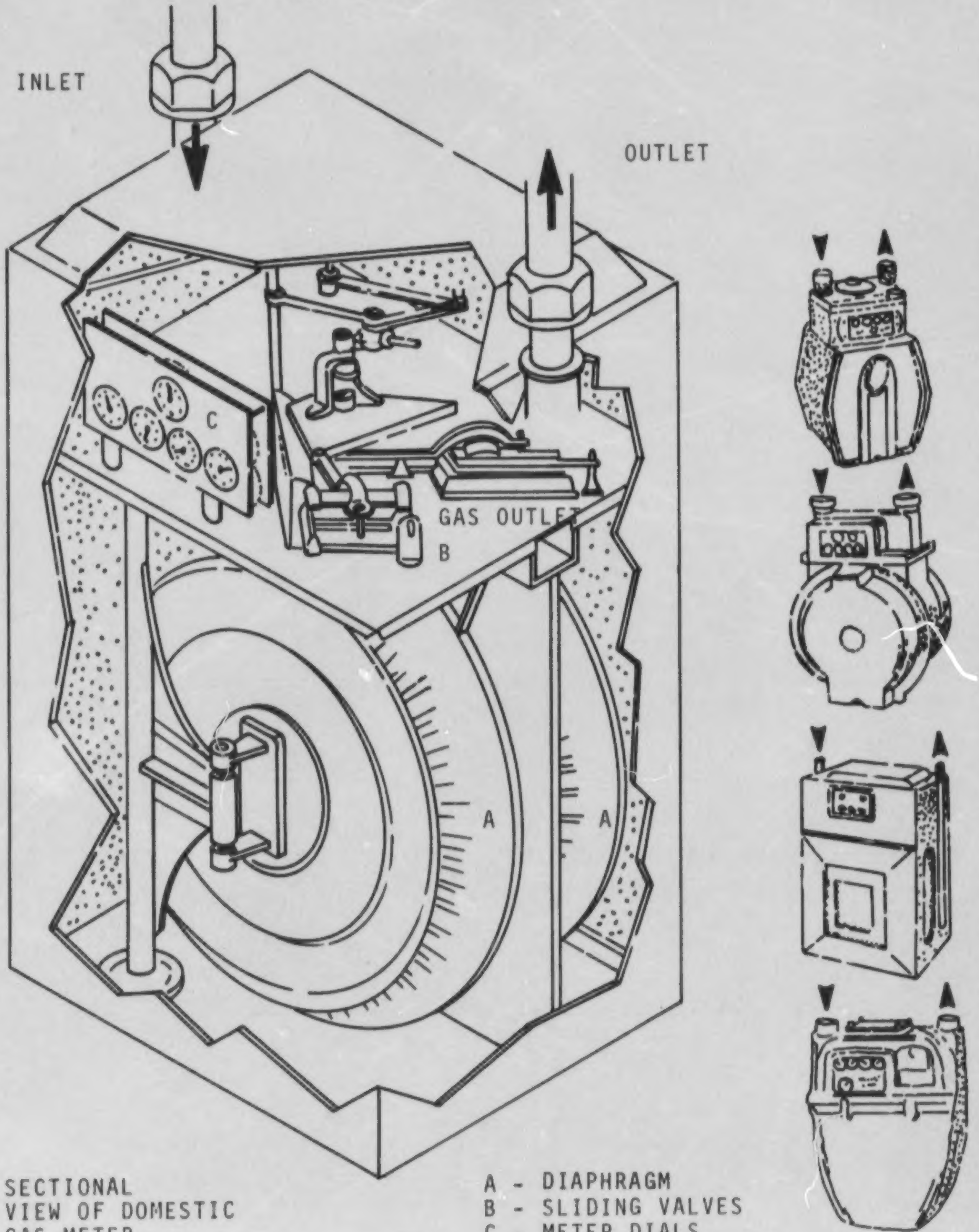
Plus a charge per kwh of energy taken for fuel cost calculated in accordance with Schedule FCF.

DETERMINATION OF DEMAND

The Demand shall be the kw supplied during the 15-minute period of maximum use during the current month, as determined by Company's demand meter, but not less than 70% of the maximum kw similarly determined during the billing months of June, July, August, September, or October in the 12 months ending with the current month, nor less than 4 kw.

FIGURE 3.4

HOW YOUR GAS METER WORKS

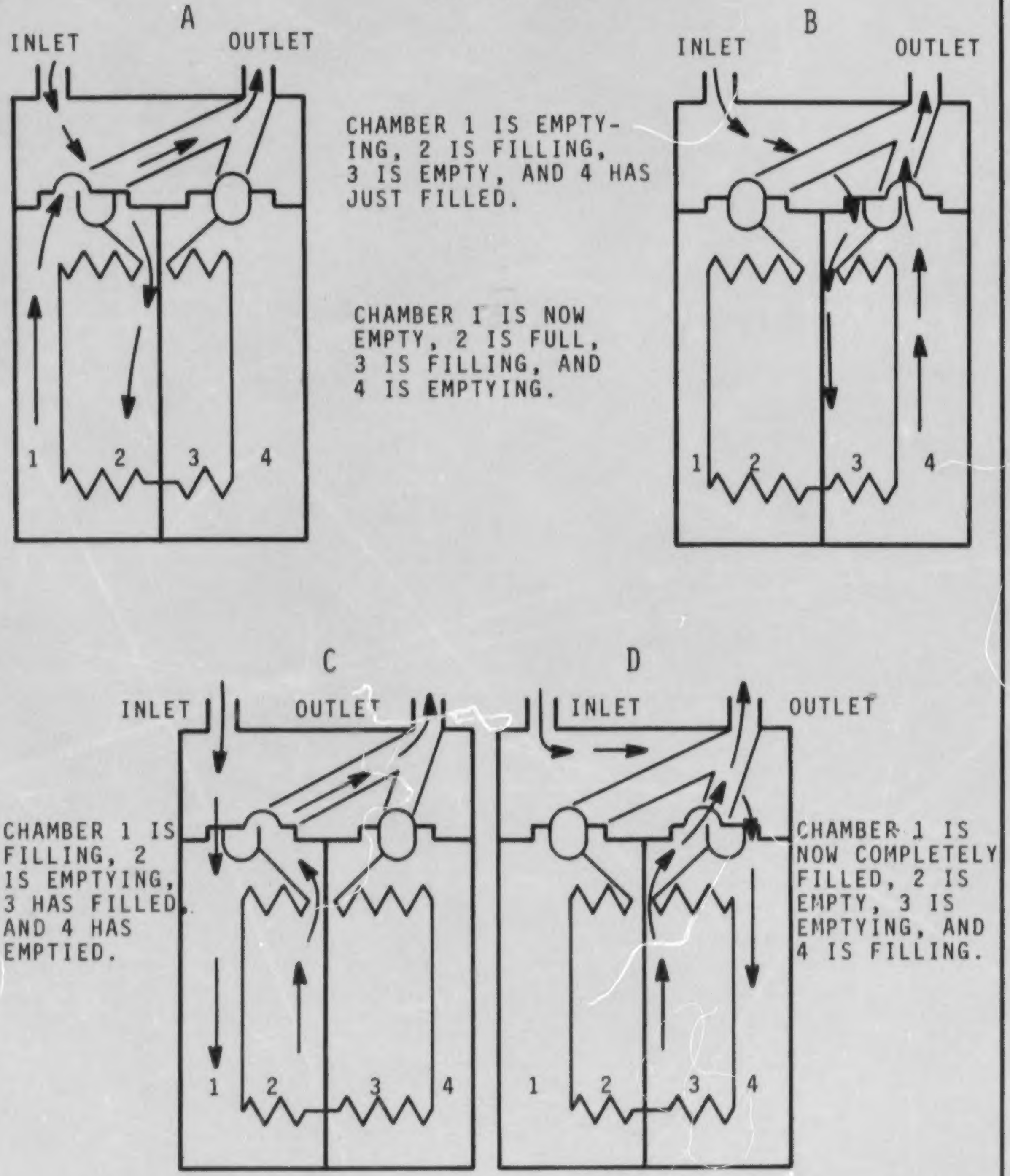

INLET
OUTLET
C
GAS OUTLET
B
A
A

SECTIONAL
VIEW OF DOMESTIC
GAS METER

A - DIAPHRAGM
B - SLIDING VALVES
C - METER DIALS

FIGURE 4.1

HERE'S HOW SLIDING VALVES CONTROL THE GAS FLOW


A
INLET
OUTLET
1
2
3
4
B
INLET
OUTLET
1
2
3
4
C
INLET
OUTLET
1
2
3
4
D
INLET
OUTLET
1
2
3
4

CHAMBER 1 IS EMPTYING, 2 IS FILLING, 3 IS EMPTY, AND 4 HAS JUST FILLED.

CHAMBER 1 IS NOW EMPTY, 2 IS FULL, 3 IS FILLING, AND 4 IS EMPTYING.

CHAMBER 1 IS FILLING, 2 IS EMPTYING, 3 HAS FILLED, AND 4 HAS EMPTIED.

CHAMBER 1 IS NOW COMPLETELY FILLED, 2 IS EMPTY, 3 IS EMPTYING, AND 4 IS FILLING.

FIGURE 4.2

HOW TO READ YOUR GAS METER

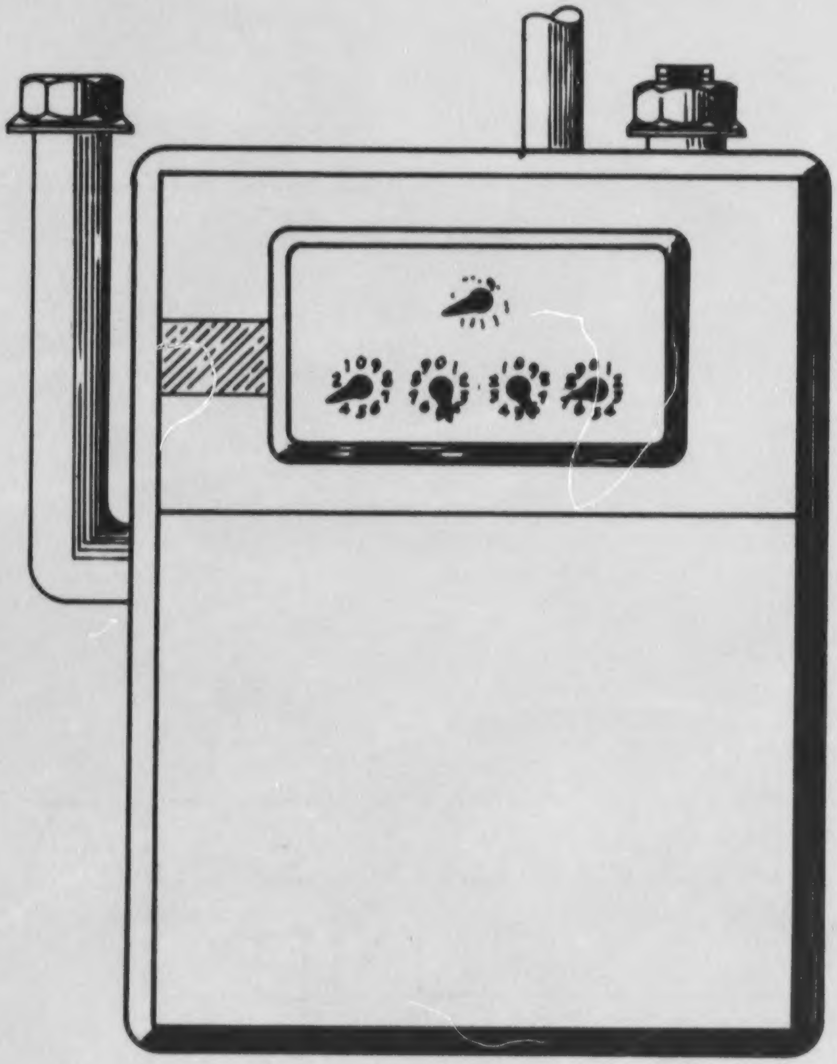
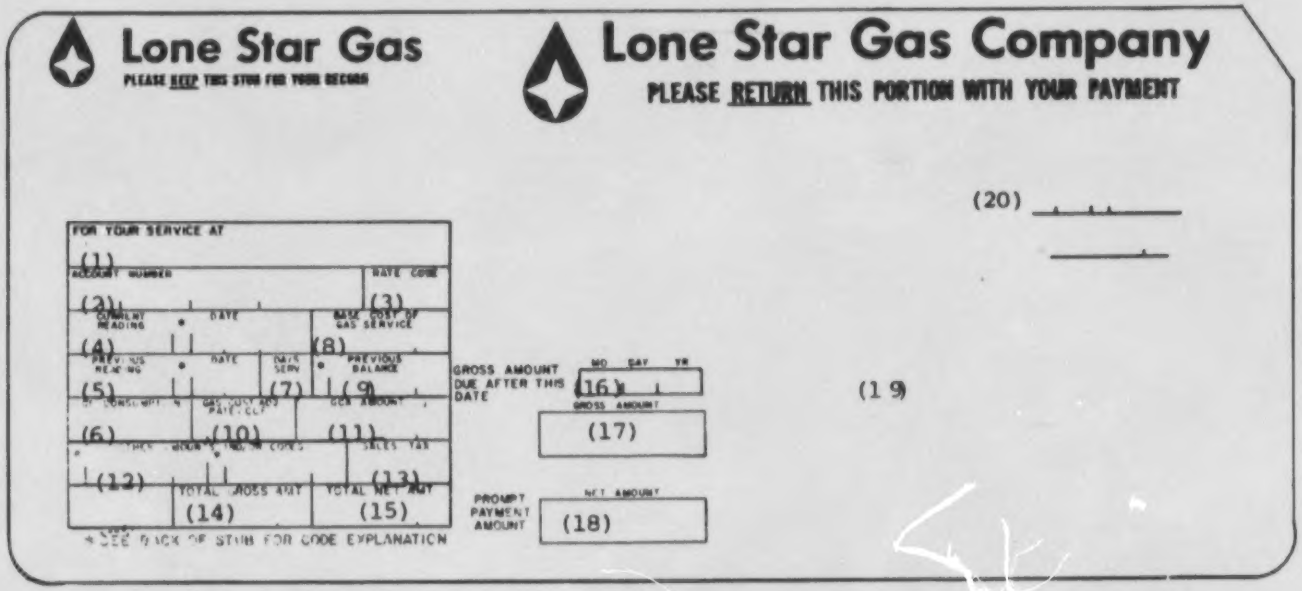


FIGURE 4.3


Lone Star Gas
PLEASE KEEP THIS STUB FOR YOUR RECORD

Lone Star Gas Company
PLEASE RETURN THIS PORTION WITH YOUR PAYMENT

FOR YOUR SERVICE AT (1)
ACCOUNT NUMBER (2)
RATE CODE (3)
CURRENT READING (4)
DATE
BASE COST OF GAS SERVICE (8)
PREVIOUS READING (5)
DATE
DAYS SERV (7)
PREVIOUS BALANCE (9)
CCF CONSUMPT (6)
GAS COST ADJ RATE/CCF (10)
GCA AMOUNT (11)
OTHER CODES (12)
SALES TAX (13)
TOTAL GROSS AMT (14)
TOTAL NET AMT (15)
* SEE BACK OF STUB FOR CODE EXPLANATION

GROSS AMOUNT DUE AFTER THIS DATE MO DAY YR (16)
GROSS AMOUNT (17)
PROMPT PAYMENT AMOUNT NET AMOUNT (18)
(19)
(20)

(21) CODE EXPLANATION

A. APPLIANCE SERVICE
B. CONNECT CHARGE
C. CREDIT
D. DEPOSIT AND/OR INTEREST APPLIED
E. ESTIMATED READING
F. FINAL BILL
G. OTHER CHARGES
H. GAS AIR CONDITIONER
M. METER EXCHANGE

BILLING EXPLANATION

CCF = HUNDREDS OF CUBIC FEET

BILLING INCLUDES AN ADJUSTMENT FOR THE INCREASE OR DECREASE IN THE PRICE THE COMPANY MUST PAY FOR NATURAL GAS PURCHSED FOR OUR CUSTOMERS. THE ADJUSTMENT FOR CHANGES IN GAS COST HAS BEEN APPROVED BY THE REGULATORY AUTHORITIES HAVING JURISDICTION IN YOUR SERVICE AREA.

(back of card)

Figure 5.1

FIGURE 5.2

TYPICAL GAS RATE SCHEDULE (WINTER)
LONE STAR GAS COMPANY

RESIDENTIAL AND COMMERCIAL RATE SCHEDULE

MONTHLY RATE:

Applicable to gas consumed between the meter reading dates of October and May of the following year.

Residential:

Customer Charge	$ 3.0000
All Consumption @	$ 2.2558 Per Mcf

If the service period is less than 28 days, the customer charge is $.1071 times the number of days of service.

Commercial:

Customer Charge	$ 6.0000
All Consumption @	$ 2.2558 Per Mcf

If the service period is less than 28 days, the customer charge is $.2143 times the number of days service.

PROMPT PAYMENT PROVISION:

Bills are due and payable when rendered and must be paid within ten (10) days* from monthly billing date.

BILLING ADJUSTMENTS:

The following adjustment is applicable if letter "T" follows the rate schedule number in the index.

The amount of each monthly bill computed at the above stated rates shall be subject to the following adjustment: Plus an amount equivalent to the proportionate part of any new tax, or increased rate of tax, or governmental imposition or charge (except state, county, city, and special district ad valorem taxes and any taxes on net income) levied or assessed against the Company or on its gas business, as the result of any new or amended law, ordiance or contract, after July 1, 1978.

The following adjustment is applicable if letter "G" follows the rate schedule number in the index.

* Fifteen (15) days for environs

The amount of each monthly bill computed at the above stated rates shall be subject to the following adjustment: An estimated city gate rate less $1.8392, multiplied by a volume expansion factor (to recover increases in gas costs associated with Unaccounted For Gas up to 5% and Company Used Gas), plus a correction factor to compensate for the second previous month's over or under recovery of increases or decreases in the city gate rate, multiplied by a tax factor.

MODULE IV

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. How to Search for Energy Conservation Opportunities may be offered independently or as a prerequisite to all or any of the modules in this series. This module is a practical search and identification of energy uses in the home.

MODULE IV

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

MODULE DESCRIPTION:

This module emphasizes the importance of recognizing energy users in the home, and developing a conscious awareness of energy efficiency and energy management. It discusses the techniques of looking for energy conservation opportunities in the home, and preparing checklists for monitoring these opportunities. Such points as usage versus load investigation, occupancy rates, and waste awareness are discussed.

GOAL STATEMENT:

The objective of this module is to train secondary and postsecondary students in the recognition of energy users in the home and the implementation of energy conservation measures to manage energy consumption and energy efficiency.

READING GRADE LEVELS:

Lecture: 12
Lab : 14

SUGGESTED TEACHING TIMES:

Secondary : 2 one-hour sessions
Postsecondary: 2 one-hour sessions

MODULE IV

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

UNIT OBJECTIVES

1. Identify energy users in the home.

2. Identify and discuss the steps necessary to accomplish energy management.

3. Identify energy management measures available in the home.

STEP 1: Walk Through Inspection
STEP 2: Amount of Time Used
STEP 3: Meter Readings
STEP 4: Historical Usage Data

SUMMARY: Energy Conservation Methods for Various Applications and Activities

MODULE IV

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

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Schiller, Carol Ann. Home Energy Management Checklist, NECEP Journal, December 1978, pp. 16-19.

Tips for Energy Savers. Washington, DC, Department of Energy (Federal Energy Administration) FEA/D-77/212 August 1977.

MODULE IV

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. In your home, there are probably more than _______ items which use energy.

   a. 10
   b. 15
   c. 25
   d. 50

2. It is important to note the wattage indicated on the labels of electric appliances that you buy.

   a. true b. false

3. One should not be concerned about turning off heat vents and closing rooms that are not in use.

   a. true b. false

4. Clean filters in your heating system can help save energy.

   a. true b. false

5. Attic insulation can save you as much as 25 percent on your heating costs.

   a. true b. false

6. The using of lids on cooking utensils will help you conserve energy.

   a. true b. false

7. Using a small pot on a large burner is a good way to conserve energy.

   a. true b. false

8. Cooling foods to room temperature before placing them in the refrigerator will make no difference in saving energy.

   a. true b. false

9. From the energy standpoint, a chest freezer is more economical than an upright freezer.

   a. true b. false

10. Weaving in and out of traffic with your automobile wastes fuel.

    a. true   b. false

11. Changing the oil and oil filter in your car will help very little in conserving fuel.

    a. true   b. false

12. Black and white television sets use more energy than color television sets.

    a. true   b. false

13. All forms of energy conservation measures are expensive.

    a. true   b. false

14. Fluorescent lighting will give you more lighting than incandescent lighting for less watts.

    a. true   b. false

15. Chilling food before placing in the freezer will help conserve energy.

    a. true   b. false

16. When cooking with water, using a great deal of water will help the food to heat quickly.

    a. true   b. false

17. Cooking outside in the summer can save energy.

    a. true   b. false

18. Keeping drapes open to allow sunlight to come into your home during the winter will help reduce your heating costs.

    a. true   b. false

19. Turning the thermostat up and down during the day saves energy.

    a. true   b. false

20. When your fireplace is not in use, it makes little difference from the standpoint of energy conservation whether the chimney is open or closed.

    a. true   b. false

MODULE IV

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

ANSWERS TO PRETEST

1. d. 50
2. a. true
3. b. false
4. a. true
5. a. true
6. a. true
7. b. false
8. b. false
9. a. true
10. a. true
11. b. false
12. b. false
13. b. false
14. a. true
15. a. true
16. b. false
17. a. true
18. a. true
19. b. false
20. b. false

MODULE IV

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

UNIT I

LECTURE	ACTIVITIES

Introduction

Energy conservation is much like being on a diet: it takes concentrated effort and a retaining of philosophy to realize your savings. On a diet we try to avoid calories; with energy conservation we try to avoid using calories or to use them most efficiently.

Learning how to search for energy conservation opportunities is the first step to reaching our ultimate goal: retraining our philosophy to become aware of energy use and energy conservation--that is, become a student of energy management.

Each module in this series will discuss measures each person can take to save energy through maintenance, operation, or construction of an energy-using device. This module will concentrate on identifying energy users in the home and developing a olan for effective energy management.

Step 1 - Walk-Through Inspection

The first step is to perform a walk-through inspection. This is simply a quick inspection to acquaint you with energy users in the home. It may surprise you to find there are more than 50 items in the home which use energy. Figure 1 will serve as a checklist for this activity. Remember, that the objective is to acquaint you with energy users in the home and to help you become familiar with the number of these devices.

STEP 2 - Amount of Time Used

Once you have identified the number of appliances and energy devices in the home, learn something about each. Go back and observe the way you operate these appliances. Note the length of time each appliance is used, and the time of day each is used. This will help you plot the peak demand period for energy in your home.

Look at appliance labels and note wattage for electric appliances, and Btu input for gas devices. Using the tables in Figure 2, determine the monthly and annual energy use for each appliances. (See Module #7 for more details on this activity.)

Step 3 - Meter Readings

(Refer to Module #5 to learn how to read a utility meter.)

Note the electric and gas meter readings at the beginning of each of five days. Before going to bed, read the meters again. Plot the amount of energy used for each of these five days and each of these five nights and note the differences in energy use. Can you begin to think of reasons for these differences?

Energy use in the home comes from a large number of different appliances and power devices. The devices listed in Tables 1 and 2 should cover most of the different appliances with their rated and expected power use and the average mean time of use that can be found in the average home assuming normal demand and use of the particular appliance. If one looks down the list and determines which appliances are used in a particulár residence and multiplies the wattage by the time of use, the daily kilowatt or watt hours or watt seconds of use can be determined.

An activity which can be used as a laboratory and demonstration exercise in the classroom consists of the following: Compare the expected times for cooking or preparation processes when using a regular oven, microwave oven, slow cooker, and oven toaster, using information in Tables 1 and 2.

Each student should, after having learned in the previous sections to read a utility meter, read the electric power and gas consumption on the smaller dials at hourly intervals for at least two days, and plot this information. In periods of high demand use, the student should read at fairly short intervals. This can be done for more than one season or for different types of weather days. Students can determine which appliances use

1. Operation practices
2. Particular activities on one day versus another day
3. An increase or decrease in the number of people in the home
4. A variance in weather temperature and conditions
5. A change in personal health conditions

This is your first major step in developing an energy management awareness.

large amounts of power by working as teams and either opening refrigerator doors, starting up the furnace or air conditioner by adjusting the thermostat, or waiting until these turn on to see how fast the meter moves and how much power is used per minute for the different types of appliances. The student can also leave a door or window open to see how infiltration rates increase the amount of time that a furnace runs.

Using the data included in the laboratory module and class modules, they should determine what their expected power use is as a function of the appliances they use in their home. To do this, they should look at the hourly expected distributions and couple this with the watt and currents that they have taken off the electrical power consumption tags and stickers on the appliances used. This will be done using information covered in previous modules and class presentation. After having plotted what their actual energy use is, they should plot a scenario of what they believe a maximum energy use could be for their home. They should also plot an energy use reduction which follows the recommendations they have learned in this and previous modules. Students should then compare all three curves to find out whether they are a medium-, a high-, or a low-power user compared betweem what they consider a maximum potential use and the minimum optimum use they have previously plotted.

APPLIANCE CHECKLIST

How many energy-using devices do you have in and around your home? It may surprise you to discover how many you have and how many you use often. Check each energy-using device in your home.

___ adding machine
___ air conditioner, central
___ air conditioner, window
___ attic fan
___ aquarium filter
___ aquarium heater
___ automobile
___ baby food warmer
___ barbeque grill
___ blanket
___ blender
___ bottle warmer
___ broiler
___ battery charger
___ clothes dryer
___ clothes washer
___ can opener
___ carving knife
___ coffee maker
___ corn popper
___ chain saw
___ clock
___ curling iron
___ calculator
___ charcoal lighter
___ dishwasher
___ deep fat fryer
___ dehumidifier
___ deodorizer
___ dog clippers
___ electrostatic air cleaner
___ evaporative cooler
___ exerciser chair
___ electric drill
___ electric saw
___ food freezer
___ food waste disposer
___ fondue pot
___ food mixer
___ fans
___ floor polisher
___ floor scrubber
___ fireplace log
___ garage door opener
___ hot plate
___ hair clippers
___ hair dryer
___ heat lamp
___ heat pad
___ hot comb/brush
___ hot lather dispenser
___ heating unit, central
___ humidifier
___ ice cream freezer
___ iron
___ lighted mirror
___ lawn edger
___ lawn mower
___ hedge trimmer
___ microwave oven
___ massager
___ movie projector
___ radio
___ range, electric or gas
___ refrigerator
___ rug shampooer
___ sewing machine
___ scissors, electric
___ slide projector
___ soldering iron
___ stereo/tape player
___ strobe light
___ swimming pool filter
___ sandwich grill
___ sharpener
___ skillet
___ shaver
___ shoe polisher
___ sun lamp
___ space heaters
___ trash compactor
___ toaster
___ toaster oven
___ toothbrush, electric
___ tape recorder
___ television
___ toys, electric
___ typewriter, electric
___ vaporizer
___ vibrator
___ vacuum cleaner
___ water heater, electric
___ water heater, gas
___ warming tray
___ water pic
___ total number of light bulbs in ceiling fixtures and table lamps

FIGURE 1

ELECTRIC APPLIANCES

Electric Product	Typical Wattage	Cost	
Air Conditioner			
Room			
Bedroom	900	$ .028*	--hour
Family or Living Area	1500	.046*	--hour
Multiple Rooms	3000	.093*	--hour
Central (EER 8)**			
3 ton	4500	.112*	--hour
5 ton	7500	.187*	--hour
Baby Food Warmer	165	.0012	--10 minutes
Blanket	175	.03*	--night
Blender	385	.0003	--minute
Broiler (Portable)	1500	.031	--30 minutes
Can Opener	100	.00007	--minute
Carving Knife	92	.0003	--5 minutes
Clock	2	.06	--month
Coffee Maker	850	.0058	--10 minutes
Cooker (Egg)	516	.0017	--5 minutes
Curling Iron	40	.0004	--15 minutes
Corn Popper	575	.006	--15 minutes
Deep Fat Fryer	1500	.038	--hour
Dehumidifier	240	.0097	--hour
Dishwasher	1200	.029	--normal cycle
Disposer	420	.0003	--minute
Dryer	5000		
Regular Fabrics		.17	--load
Permanent Press		.13	--load
Electrostatic Cleaner	50	1.50	--month (continuous fan operation)

FIGURE 2

Electric Heating**			
Heat Pump (January Average)	15000	.105*	--hour
Baseboard (January Average)	15000	.138*	--hour
Furnace (January Average)	15000	.159*	--hour
Fans			
Attic	375	.0151	--hour
Circulating	88	.0037	--hour
Exhaust - small	200	.0083	--hour
Furnace (1/3 h.p.)	330	.0096	--hour
Rollabout	171	.0070	--hour
Window	200	.0086	--hour
Floor Waxer/Cleaner	350	.0145	--hour
Fondue/Chafing Dish	800	.016*	--hour
Freezer (15 cu. ft.)	341	4.35*	--month
Frostless (15 cu. ft.)	440	6.10*	--month
Fry Pan	1150	.03*	--hour
Garden Tools			
Edger	190	.0039	--30 minutes
Hedge Trimmer	265	.0055	--30 minutes
Garage Door Opener	350	.00024	--minute
Grinder (Food or Coffee)	150	.001	--10 minutes
Griddle	1200	.019*	--30 minutes
Hair Clipper	10	.00007	--10 minutes
Hair Dryer			
Soft Bonnet	400	.0166	--hour
Hard Bonnet	900	.0374	--hour
Hand Held	600	.0249	--hour
Hair Rollers	350	.0036	--15 minutes
Heat Lamp	250	.0104	--hour
Heating Pad	65	.0015*	--hour
Hi-Fi/Stereo	100	.00415	--hour
Hot Plate	1250	.026	--30 minutes
Humidifier	175	.02	--day
Ice Cream Freezer	130	.004	--45 minutes
Ice Crusher	120	.00041	--5 minutes
Iron	1000	.0228*	--hour

Juicer	90	.00006	--minute
Knife Sharpener	100	.00035	--5 minutes
Lights*** - 100-watt bulb	100	.0415	--10 hours
Make-up Mirror	25	.00026	--15 minutes
Microwave Oven	1500	.005	--5 minutes
Mixer			
Hand	100	.0021	--30 minutes
Standing	150	.0031	--30 minutes
Motors****			
1/6 h.p.	170	.0004	--5 minutes
1/4 h.p.	250	.0006	--5 minutes
1/3 h.p.	330	.0008	--5 minutes
1/2 h.p.	500	.0012	--5 minutes
1 h.p.	1000	.0024	--5 minutes
Power Tools			
Drill (1/4 inch)	240	.0009	--5 minutes
Jig Saw	370	.00128	--5 minutes
Radio	75	.0031	--hour
Range			
Small Surface Unit	1300	.015	--15 minutes (high heat)
Large Surface Unit	2400	.009	--5 minutes (high heat)
Oven (non-self-cleaning)	3200	.043*	--hour
(self-cleaning)	3200	.034*	--hour
Broiler Unit	3600	.037	--15 minutes
Self-Cleaning Feature	4000	.15-.25*	--2 hours
Refrigerator/Freezer (14 cu. ft.)	330	4.16*	--month
Frostless	615	6.35*	--month
Roaster	1350	.034*	--hour
Sewing Machine	75	.0031	--hour
Shaver	14	.00005	--5 minutes
Shaving Cream Dispenser (Heated)	60	.00004	--minute

Slow Cooker - Low	75	.0031	--hour
High	150	.0062	--hour
Space Heater	1300	.054	--hour
Sump Pump (1/3 h.p.)	330	.0096	--hour
Sun Lamp	250	.0017	--10 minutes
Television			
Black & White	160	.0066	--hour
Solid State	55	.0023	--hour
Color	300	.013	--hour
Solid State	200	.0083	--hour
Toaster	1200	.0016	--2 minutes
Toothbrush	7	.000005	--minute
Trash Compactor	400	.0014	--5 minutes
Vacuum Cleaner	650	.027	--hour
Vaporizer			
Cool Mist	60	.0025	--hour
Steam	480	.0200	--hour
Waffle Iron	1200	.02*	--30 minutes
Warming Tray	140	.006	--hour
Washing Machine (Automatic)	500	.011	--normal load
Water Heater (Quick (Recovery)	4500	.10-.20	--per person/day
Yard or Post Lights			
175w Mercury (Bulb & Ballast)	196	.09	--night
100w Incandescent (Both based on photo-cell control--normal operating hours for one year -- 4,000)	100	.05	--night

Note: Costs exclude 3% sales tax.

* Thermostatically controlled. Cost based upon estimated percentage of "On" time.

**ELECTRIC HEATING AND CENTRAL AIR CONDITIONING COSTS VARY WITH EACH INDIVIDUAL HOME. MANY FACTORS ARE NEEDED TO ARRIVE AT AN ACCURATE ESTIMATE: SIZE OF HOME, TYPE OF SYSTEM, AMOUNT OF INSULATION, NUMBER OF DOORS, WINDOWS, ETC.

***MANY FACTORS AFFECT LIGHTING COSTS: SIZE OF THE HOME, TYPE OF LIGHTING, ETC. BUT KEEP IN MIND -- FLUORESCENT LIGHTS ARE MORE EFFICIENT AND MORE ECONOMICAL TO OPERATE.

****MOTORS FOR FURNACES, APPLIANCES, TOOLS, PUMPS, ETC. ARE RATED BY OUTPUT HORSEPOWER (H.P.), BUT DEPENDING ON SIZE, QUALITY AND LOAD CHARACTERISTICS THE WATTAGE RATING VARIES. IN GENERAL, 1 H.P. OUTPUT EQUALS 1000 WATTS INPUT AT FULL LOAD. HOWEVER, MOTORS ARE GENERALLY SIZED TO RUN AT 70% FULL LOAD.

GAS APPLIANCES

Gas Appliance	Typical Gas Input Rating CFH	Cost	
Air Conditioners**			
Central 3 ton	80	.140*	--hour
Central 5 ton	135	.235*	--hour
Dryer			
Regular Fabrics	25	.062*	--load
Permanent Press	18	.050*	--load
Furnace**			
(January Average)	137	.073*	--hour
Outdoor Grill (Full heat)	25	.0242	--30 minutes
Range			
Surface Unit	6	.001	--5 minutes
Oven	30	.030*	--hour
Water Heater	37	.05-.10	--per person/day
Yard Light	2	.092	--day

Note: Cost includes both gas and associated electrical energy use for appliances, but excludes 3% sales tax.

* Thermostatically controlled. Cost based upon estimated percentage of "On" time.

** Natural gas heating and air conditioning costs vary with each individual home. Many factors are needed to arrive at an accurate estimate: size of home, type of system, amount of insulation, number of doors, windows, etc.

Step 4 - Historical Usage Data

It is now necessary to compare energy used for this month with energy used last month and with energy used this month last year. In order to be energy-conscious, the student must know what the energy demands are in the home so that monitoring can result in a change in operating habits, maintenance, or kind of appliances used and reduce the amount of energy consumed.

Step 5 - Prioritize the Energy Use

Look at the survey taken and indicate the appliances and devices which require the most energy. Based on the list at Figure 3, survey your home for energy conservation measures you have done or can do to make your energy consumption more efficient.

Students should proceed before a specifically assigned class to gather copies of at least one, and preferably two, years of utility bills used by their family. The actual dollar amounts are of no interest in this exercise. The student should get the kilowatt/hours of electricity and the thousand cubic feet of natural gas that were billed for each month from the receipts. It would be helpful also to tally water bills for the same period with respect to the number of gallons or cubic feet of water used.

In this activity, the students are to use graph paper to plot the monthly power requirements: namely the electricity and gas used, as a function of months of the year. Per the example in Figure 2, put the months along the ordinate and the gas use up the right hand abscissa and the electric use up the left hand abscissa.

Once this has been plotted the students should determine what the base line loads are as a function of season and the overall yearly base line load. This is the power demand at the minimum period during the whole year or the minimum power required for the period of either the winter heating or the summer cooling season. Students should also determine the peak profile structure and the peak demands for power.

The information will give them an idea of what power use demands are in their particular home.

A SUMMARY OF ENERGY CONSERVATION METHODS FOR VARIOUS APPLICATIONS AND ACTIVITIES

After considering the conservation aspects of all the models and specifics of this module, one can summarize in numerical form what the better conservation activities and lifestyle approaches are that help reduce energy costs and utility bills. In general, a customer benefits from energy conservation because it:

1. Cuts down on utility and gasoline bills,
2. Helps fight pollution,
3. Saves natural gas, petroleum, and electricity now, so that such energy will be available longer.

Energy conservation methods are grouped under specific appliances and uses. The first list is for general residential and small commercial use, and the second list is for industrial and business use. However, many of the energy conservation practices for business and industry are directly applicable to the home, especially for those with electrical-electronic and audio-visual equipment.

I. GENERAL RESIDENTIAL AND SMALL COMMERCIAL CONSERVATION METHODS

A. Heating

1. In cooler months of the year, set the thermostat at 68° during the daytime, and several degrees lower at night (an extra blanket on your bed can make up the difference).
2. Set the thermostat at a comfortable temperature, then leave it alone...turning it up and down wastes energy.
3. Make sure the home has adequate insulation -- install storm windows and doors if not already in place. Three inches of insulation in attic can save as much as 25 percent on heating cost over no insulation.
4. Avoid frequent opening of outside doors. Use weatherstripping to seal air leaks around edges.
5. In winter, keep drapes open to let the sunlight in during the day; close them at night to stop cold drafts.
6. Keep the chimney damper closed when the fireplace is not in use.
7. Turn off heat vents and close off rooms that are not in use.
8. Keep filters clean...change them at least twice a year.
9. Consider a switch to solar heating in the future.
10. Remove furniture, rugs, etc., that block heating vents or radiators.
11. Place aluminum foil between radiator and exterior wall to reflect heat into the house.

FIGURE 3

B. Cooling

1. During hot months, set the temperature on "low" or keep the thermostat at 78° or more...this way less electricity will be used and occupants will feel less uncomfortable when you step outdoors.
2. In summer, close drapes to keep sunlight out to make it easier for the air conditioner to keep things cool.
3. Install a window air conditioner in the window with the most shade during the day.
4. Use heat-producing major appliances (dishwashers, dryers, ovens, etc.) during early morning or evening...not when the outside temperature is the highest.
5. Keep doors and windows closed when air conditioner is operating...and close off unused areas.
6. Keep filters clean.
7. Set the thermostat higher if the family is away most of the day and turn it off if you're going away for a weekend or longer.
8. Storm windows will help keep the cool air inside.
9. To ease the load on the air conditioning system, consider installing an attic fan to help blow out the trapped hot air.
10. Make sure sofas, bookcase, and other solid objects do not obstruct the air conditioning unit to help keep it operating efficiently.

C. Water Heating

1. Set the water heater thermostat at medium.
2. Take showers, which use less hot water than tub baths.
3. Fix leaky faucets (a drip a second wastes 700 gallons a year).
4. Don't wash dishes under running water...a dishwasher uses less hot water than hand-washing.
5. Run washing machine, dryer, and dishwasher only with full loads. Wash clothes in cold water whenever possible.
6. When on vacation, set the water heater to the vacation setting. The pilot light will keep burning without using more energy to heat water. (Better still, turn the pilot light off.)
7. Don't waste hot water. For example, don't leave water running while washing hands or shaving--partially fill the basin first.

D. Lighting

1. Turn off lights when not needed.
2. Keep light bulbs and fixtures clean...brighter light may require fewer bulbs.
3. When possible, use fluorescent lamps. A 40-watt fluorescent lamp produces more light than a 100-watt incandescent bulb.
4. Install dimmer controls to save energy and add atmosphere where appropriate.
5. Use pastel walls and a light-colored interior decor, which usually requires fewer lamps.

E. Major Appliances--Kitchen Stove

1. Partially thaw frozen foods before cooking.
2. Put small pots on small burners, large ones on large burners.
3. Cover pots to avoid heat loss and reach cooking temperature quickly.
4. Use high setting on units to start, then reduce heat and food will continue to boil.
5. When cooking with water, use as little as possible so food will heat quickly.
6. When using the oven, preheat only 10 minutes...and don't peek. The oven uses less energy than the stove top because it is a confined space.
7. Avoid using aluminum foil on shelves directly under pans since it can reflect the heat away from them.
8. Cook by time and temperature. A meat thermometer can eliminate over-cooking. Precise timing eliminates heat wasted by peeking.
9. In summer, cook outdoors whenever possible to reduce heat build-up inside. Experiment with a solar cooker.
10. When using gas, regulate burners so flame tips just touch utensil bottoms.
11. A clean oven and broiler cooks more efficiently.
12. Ceramic, glass and stainless steel are best heat retainers (lower oven temperatures by 25°).

F. Major Appliances--Refrigerator/Freezer

1. Locate refrigerator out of sun and away from heat sources (stove, dishwasher, etc.)
2. Cool foods to room temperature before placing them in refrigerator.
3. Make sure gasket seals door well.
4. Defrost freezer when 1/4" of frost has built up.
5. Keep freezer full, but not overloaded: less energy is required to keep freezer cold when air can easily circulate around packages.
6. Chill food before placing it in freezer...and don't freeze too many things at once.
7. A chest freezer is more economical than an upright because when the door is opened the cold air settles on the bottom, rather than flowing onto the floor.
8. To avoid excess cold loss, open refrigerator or freezer only when necessary.
9. Check the temperature setting of your refrigerator and freezer against your appliance manual. If you store your food too cold, you will be wasting energy.
10. When preparing to go on vacation, set refrigerator at a warmer temperature and leave it fairly empty.

G. Major Appliances--Washer & Dryer

1. Keep the lint traps clean to assure top efficiency.
2. Use only when full and as cool a setting as possible (DO NOT OVERLOAD).
3. Use the water level control on your washer...small loads require less hot water.

4. Don't overdry clothes. Save ironing by hanging or folding clothes as soon as they are dry.
5. Your dryer should be located where it has easy access to clean dry air.
6. Use the free solar energy whenever possible.
7. Soak stubborn stains before washing.
8. Check type of soiling and fabric--when possible, wash clothes in cold water (except diapers).

H. Transportation

1. Reduce the amount of driving you must do...instead of five or six short trips, make one well-planned and organized trip.
2. Use car pools to get to work, take kids to school, or even for shopping trips.
3. Use public transportation whenever possible.
4. Use a bicycle for short trips...uses less energy and keeps you in shape at the same time...Or walk.
5. Consider buying a smaller, more efficient car.

I. Automobile

1. Avoid jackrabbit starts and sudden stops.
2. Avoid weaving in and out of traffic; this wastes fuel and can cause needless accidents.
3. Save gasoline by turning off the car motor while waiting for someone.
4. Hold a constant driving speed when possible. Consider cruise control.
5. On hot summer days, park in the shade so the air conditioner doesn't have to work as hard. When possible, drive with the windows open.
6. Keep the car in top shape...have it tuned regularly.
7. Make sure tires are properly inflated to increase gas mileage and reduce wear.
8. If you are a two-car family, use the smaller one for running errands.
9. Change oil and oil filters every 3,000 to 6,000 miles (according to the owner's manual for particular model). A dirty engine wastes gas.
10. Improper wheel alignment cuts down on power, gas mileage, and tire mileage.

J. Appliances--General

1. Follow detergent directions carefully. Oversudsing in both dish and clothes washers uses extra energy because the equipment must work harder (try a low-suds product).
2. Use small appliances rather than large ones, when possible. For example, an electric fry pan uses less energy than an electric range burner in cooking a one-pot meal.
3. Iron all clothes at the same time to avoid reheating iron later in day or several times in one week.
4. Have gas appliances cleaned regularly so they will always operate at top efficiency.
5. Motor-driven appliances, like mixers, are particularly economical. Try hand mixing also.

K. Miscellaneous

1. Color television sets use more energy than black and white.
2. Always turn off a radio, TV, or record player when no one is watching or listening.
3. When possible, use major appliances during off-peak hours (before 8 a.m. and after 6 p.m.), when commercial and industrial use is less.
4. Keep a swimming pool in top operating condition so it doesn't waste energy.
5. Recycle aluminum, paper, and glass whenever possible.
6. Watch lawn watering...water is wasted when a lawn becomes saturated and the water starts running into the street.
7. Avoid using extension cords for major appliances and don't overload circuits. Overloading causes reduced energy efficiency.
8. Make the family aware of the energy problem and what they can do about it!

II. INDUSTRIAL AND BUSINESS

A. Heating

1. Install sufficient insulation.
2. Set the thermostat at 68° or slightly lower during the winter. (66-70° is recommended for factory areas, 72-74° for general office areas.) Avoid over-heating areas.
3. Cut heat leakage from building by using caulking and weather stripping around doors and windows.
4. Make sure heat is not left on too far into spring.
5. Reduce or turn off heat in unused areas (warehouses, docks, etc.).
6. Install automatic door closers on outside doors so they are not left open, thus heating the outdoors.
7. Reduce heating during those times when the space is unoccupied.
8. Check with equipment suppliers or qualified engineers to determine the extent to which heating, ventilating, and cooling equipment is suited for its job...is it the best?
9. Consider the practicality of infra-red heaters in high bay areas and warehouses. (It requires less fuel than other kinds of heating because it only heats solid objects in its path...not the air in between.)

B. Cooling

1. Keep the thermostat set at 72° or higher during the summer. Avoid overcooling.
2. Spray water on building roofs to reduce the effects of solar heat.
3. Close off unused areas.
4. Install automatic door closers on outside doors so they are not left open, thus cooling the outdoors.

C. Maintenance of Equipment

1. Emphasize boiler maintenance. Cleanliness improves its operation.
2. Check stack temperature to be sure of complete combustion.
3. Check the insulation on heat/cold pipes--machines will work extra hard because of leaks or a lack of proper insulation.
4. Inspect heat transfer surfaces regularly to make sure they are clean...insuring top efficiency.
5. Be on the alert for hot spots and deterioration in furnaces and pipe systems. (Air leaking into furnaces can cause large losses.)
6. Make sure furnace controls and burners are maintained for best efficiency.

D. Electricity

1. Turn off lights in empty rooms except where needed for safety and security (i.e., washroom lights).
2. Where possible, use fluorescent lighting rather than incandescent bulbs (for more lighting for less watts).
3. Turn off electrical equipment when not in actual use (e.g., typewriter while using the telephone).
4. Check and justify weekend electrical power usage.
5. Keep motor actuating controls in proper condition so that motors will not operate unnecessarily.
6. Install automatic controls for outdoor and indoor lighting so electricity is not wasted.
7. Convert to higher voltage electrical systems where practical.

E. Transportation

1. Reduce amount of driving...organize errands into one well-planned and organized trip rather than many short trips.
2. Encourage car pooling and the use of public transportation.
3. Whenever possible, ship freight by rail rather than by air... it requires less energy.
4. Keep company cars and trucks in top-shape...have them turned regularly.

F. Operation of Equipment

1. Avoid short runs on thermal process equipment when possible and shut down or idle equipment during production interruptions.
2. In many areas, energy waste is often the result of long-unquestioned plant practices that can be shown to have no effect on employee performance or product dependability... re-evaluate.
3. Schedule loads so equipment operates at top level of efficiency.

4. If possible, reschedule some electrical usage to off-peak periods when voltage remains high (before 8 a.m. or after 6 p.m.).

G. Miscellaneous

1. Recover waste heat from burner stacks and industrial processes use when possible.
2. Recycle waste materials (sawdust, oil, etc.) as supplemental fuels where possible.
3. Consider the use of heat pipes for transporting required heat or dissipating unwanted excess heat.
4. Check for accuracy of deliveries of oil, gases, etc.
5. Investigate "new" forms of energy.

These lists were developed using material from the Edmund Scientific Company Manual No. 9903.

Step 6--Prioritize Energy Solutions

Some energy conservation measures are expensive, while others require no expense at all (e.g., turning down a thermostat). Prioritize the energy measures which require expense in order to devise a scheme for implementing them. Some measures may be too expensive to implement at present, while others may be too expensive to even consider in terms of payback. (Refer to Module #11 for cost factors and information.)

Summary

Effective energy management requires work. It is a two-part activity: first, recognize your problem; second, do something about it.

Energy management requires surveying usage periodically, keeping records, and prioritizing energy solution measures. Once the students understand this process of energy management, or how to search for energy conservataion opportunities, they will be able to realize energy and monetary savings.

To determine the energy efficiency of your home as a building, complete the survey form at Figure 4 and discuss it in class.

E-OK ENERGY EFFICIENT

The N.E.W. Way to an Energy Efficient Home
Rating Sheet

STRUCTURAL ENERGY INTEGRITY ITEMS	Assigned Points	Structural Points
1. GLASS AREAS (Windows, French and Patio Doors, etc.)		
A. Percent of Glass Area to Floor Area		
Less than 8%	20	
8% to less than 10%	17	
10% to less than 12%	12	
12% to less than 15%	6	
15% to less than 20%	0	
20% to less than 25%	−15	
Greater than 25%	−30	______
B. Type and Amount of Glass		
Single Glazed	0	
Storm or Double Glazed without Thermal Break		
100% of Glass Area	20	
80% to less than 100% of Glass Area	16	
60% to less than 80% of Glass Area	12	
40% to less than 60% of Glass Area	8	
20% to less than 40% of Glass Area	4	
Less than 20% of Glass Area	0	
Storm or Double Glazed with Thermal Break		
100% of Glass Area	25	
80% to less than 100% of Glass Area	20	
60% to less than 80% of Glass Area	15	
40% to less than 60% of Glass Area	10	
20% to less than 40% of Glass Area	5	
Less than 20% of Glass Area	0	______
2. EXTERIOR DOORS (Other Than Glass)		
Solid or Hollow Core	0	
Insulated or Storm Door	4	______
3. FLOORS		
Monolithic Slab - with no Perimeter Insulation	0	
Monolithic Slab - with R-5 Perimeter Insulation	5	
Pier & Beam with R-11 Insulation	0	
Pier & Beam with R-19 Insulation	10	
Pier & Beam with Less than R-11 Insulation	−15	______
4. OUTSIDE WALLS		
Less than R-7 Insulation Installed	−20	
Less than R-11 Insulation Installed	−10	
R-11 Insulation Installed	0	
R-13 Insulation Installed	10	
R-16 Insulation Installed	15	
R-18 Insulation Installed	17	
R-23 Insulation Installed	20	______
5. CEILINGS OVER CONDITIONED AREAS		
R-19 Insulation Installed	0	
R-22 Insulation Installed	12	
R-26 Insulation Installed	20	
R-30 Insulation Installed	25	
R-38 Insulation Installed	30	______
6. INFILTRATION OF UNCONDITIONED AIR *		
A. Soleplate Sealed	13	______
B. Wiring & Plumbing Holes and Furrdowns Sealed	10	______
C. Exterior Doors & Windows Weather Stripped	3	______
D. Exterior Doors & Windows Rough Openings Caulked	6	______
E. Attic Access in Conditioned Space Weather Stripped	2	______
F. Outside Sheathing Holes Sealed and Polyethylene Film** Installed	3	______
G. Ventless or Dampered Range Hood Installed	3	______
7. FIREPLACES		
No Fireplace	10	
Fireplace with Damper, Glass Screen & Make Up Air Intake	8	
Fireplace with Damper & Make Up Air Intake	5	
Fireplace with Damper [illegible]	0	
Fireplace without Damper	−15	______
STRUCTURAL ITEMS SUB-TOTAL Required Points	90	☐

MECHANICAL SYSTEM ITEMS	Assigned Points	Mechanical Points
8. ATTIC VENTILATION REQUIREMENT (See Table for Vent Area Required)		
With no Air Handler and/or Duct System in the Attic - 0.4 to 1.0 cfm per sq. ft. of Attic Floor Area "OR" With Air Handler and/or Duct System in the Attic - 1.5 to 2.0 cfm per sq. ft. of Attic Floor Area	5	______
9. DUCT SYSTEM		
Attic Space R-7 Sealed Joints	0	
Attic Space R-14 Sealed Joints	5	
Unconditioned Space or Partial Conditioned	5	
None or Conditioned Space (R-4)	15	______
10. AIR HANDLER AND/OR HEATING UNIT LOCATION		
Attic Space	0	
Unconditioned Space (Combustion Air to Closet puts the Unit in an Unconditioned Space)	5	
Conditioned Space	15	______
11. COOLING EFFICIENCIES (Unitary, Window Units, & Heat Pumps) at 95° Outdoor Temperature (ARI Rating or AHAM)		
A. 7.0 EER	0	
7.1 to less than 7.5	5	
7.5 to less than 8.0	10	
8.0 to less than 8.5	15	
8.5 to less than 9.0	20	
9.0 to less than 9.5	25	
9.5 or Greater EER	30	______
B. Single Unit	0	
Multiple Unit	5	______
12. HEATING EFFICIENCIES 47° Outdoor Temperature		
COP .5 to less than 1.0	0	
1.0 to less than 2.0	8	
2.0 to less than 2.5	12	
2.5 to less than 3.0	16	
3.0 to less than 3.5	20	
3.5 or Greater	24	______
13. WATER HEATING SYSTEM		
A. Pipe Insulation		
Lines Insulation - Non Circ. System (R-4)	5	
Not Insulated - Non Circ. System	0	
Circ. System	−50	______
B. Water Heating Location		
Located within 20 ft. of Kitchen & Utility Area	3	______
C. Heat Recovery or Solar Water Heating	15	______
STRUCTURAL & MECHANICAL ITEMS TOTAL Required Points	135	☐

Remember, an E-OK home must earn at least 135 points, and a minimum of 90 of these points must be achieved in construction categories 1 through 7. If the original point rating of your present home in categories 1 through 7 has been increased by a minimum of 35 points, you still qualify for the N.E.W. program.

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*The right is reserved to test the structure for infiltration when less than one air change per hour is claimed by Point System.

**This is mandatory when a High Order Vapor Barrier is used on the outside wall.

TEXAS POWER & LIGHT COMPANY

NATIONAL ENERGY WATCH

FIGURE 282

MODULE IV

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

POSTTEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. Attic insulation can save you as much as _______ percent on your heating costs.

   a. 5
   b. 10
   c. 25
   d. 70

2. A dirty filter in your heating system does not cause an increased utilization of energy.

   a. true b. false

3. You can save energy by turning off heat vents and closing rooms that are not in use.

   a. true b. false

4. There are probably more than 50 items in your home that use energy.

   a. true b. false

5. You should not be concerned about the wattage indicated on the labels of electric appliances. This is only for the professional electrician.

   a. true b. false

6. If you want to conserve fuel, the changing of oil and oil filters in your automobile is important.

   a. true b. false

7. There is little difference in the operation of an upright freezer and a chest freezer.

   a. true b. false

8. Your automobile does not use extra fuel when you weave in and out of traffic.

   a. true b. false

9. If you use a small pot on a small burner rather than on a large burner, you will conserve energy.

   a. true b. false

10. If you cool foods to room temperature before you place them in the refrigerator, you will save energy.

   a. true b. false

11. Lids on cooking utensils do very little to help you conserve energy.

   a. true b. false

12. If you cook outside in the summer, you will very likely waste energy.

   a. true b. false

13. When you cook with water, use as little as possible. This will help the food to heat quickly and therefore save energy.

   a. true b. false

14. If you chill foods before you place them in the freezer you will waste energy.

   a. true b. false

15. Incandescent lighting will give you more lighting than fluorescent lighting for less watts.

   a. true b. false

16. There is no difference in the amount of energy utilized by black and white and color television sets.

   a. true b. false

17. It is very likely that any kind of conservation measure you institute will be expensive.

   a. true b. false

18. If you keep your drapes open to allow sunlight to come into your home during the winter, you will reduce your heating costs.

   a. true b. false

19. Turning the thermostat up and down during the day wastes energy.

   a. true b. false

20. If your fireplace is not in use, you should keep the chimney open in order to increase convection and thereby conserve energy.

   a. true b. false

MODULE IV

HOW TO SEARCH FOR ENERGY CONSERVATION OPPORTUNITIES

ANSWERS TO POSTTEST

1. c. 25
2. b. false
3. a. true
4. a. true
5. b. false
6. a. true
7. b. false
8. b. false
9. a. true
10. a. true
11. b. false
12. b. false
13. a. true
14. b. false
15. b. false
16. b. false
17. b. false
18. a. true
19. a. true
20. b. false

APPLIANCE CHECKLIST

How many energy-using devices do you have in and around your home? It may surprise you to discover how many you have and how many you use often. Check each energy-using device in your home.

____adding machine
____air conditioner, central
____air conditioner, window
____attic fan
____aquarium filter
____aquarium heater
____automobile
____baby food warmer
____barbeque grill
____blanket
____blender
____bottle warmer
____broiler
____battery charger
____clothes dryer
____clothes washer
____can opener
____carving knife
____coffee maker
____corn popper
____chain saw
____clock
____curling iron
____calculator
____charcoal lighter
____dishwasher
____deep fat fryer
____dehumidifier
____deodorizer
____dog clippers
____electrostatic air cleaner
____evaporative cooler
____exerciser chair
____electric drill
____electric saw
____food freezer
____food waste disposer
____fondue pot
____food mixer
____fans
____floor polisher
____floor scrubber
____fireplace log
____garage door opener
____hot plate
____hair clippers
____hair dryer
____heat lamp
____heat pad
____hot comb/brush
____hot lather dispenser
____heating unit, central
____humidifier
____ice cream freezer
____iron
____lighted mirror
____lawn edger
____lawn mower
____hedge trimmer
____microwave oven
____massager
____movie projector
____radio
____range, electric or gas
____refrigerator
____rug shampooer
____sewing machine
____scissors, electric
____slide projector
____soldering iron
____stereo/tape player
____strobe light
____swimming pool filter
____sandwich grill
____sharpener
____skillet
____shaver
____shoe polisher
____sun lamp
____space heaters
____trash compactor
____toaster
____toaster oven
____toothbrush, electric
____tape recorder
____television
____toys, electric
____typewriter, electric
____vaporizer
____vibrator
____vacuum cleaner
____water heater, electric
____water heater, gas
____warming tray
____water pic
____total number of light bulbs in ceiling fixtures and table lamps

FIGURE 1

ELECTRIC APPLIANCES

Electric Product	Typical Wattage	Cost	
Air Conditioner			
Room			
Bedroom	900	$ .028*	--hour
Family or Living Area	1500	.046*	--hour
Multiple Rooms	3000	.093*	--hour
Central (EER 8)**			
3 ton	4500	.112*	--hour
5 ton	7500	.187*	--hour
Baby Food Warmer	165	.0012	--10 minutes
Blanket	175	.03*	--night
Blender	385	.0003	--minute
Broiler (Portable)	1500	.031	--30 minutes
Can Opener	100	.00007	--minute
Carving Knife	92	.0003	--5 minutes
Clock	2	.06	--month
Coffee Maker	850	.0058	--10 minutes
Cooker (Egg)	516	.0017	--5 minutes
Curling Iron	40	.0004	--15 minutes
Corn Popper	575	.006	--15 minutes
Deep Fat Fryer	1500	.038	--hour
Dehumidifier	240	.0097	--hour
Dishwasher	1200	.029	--normal cycle
Disposer	420	.0003	--minute
Dryer	5000		
Regular Fabrics		.17	--load
Permanent Press		.13	--load
Electrostatic Cleaner	50	1.50	--month (continuous fan operation)

FIGURE 2

Electric Heating**			
Heat Pump (January Average)	15000	.105*	--hour
Baseboard (January Average)	15000	.138*	--hour
Furnace (January Average)	15000	.159*	--hour
Fans			
Attic	375	.0151	--hour
Circulating	88	.0037	--hour
Exhaust - small	200	.0083	--hour
Furnace (1/3 h.p.)	330	.0096	--hour
Rollabout	171	.0070	--hour
Window	200	.0086	--hour
Floor Waxer/Cleaner	350	.0145	--hour
Fondue/Chafing Dish	800	.016*	--hour
Freezer (15 cu. ft.)	341	4.35*	--month
Frostless (15 cu. ft.)	440	6.10*	--month
Fry Pan	1150	.03*	--hour
Garden Tools			
Edger	190	.0039	--30 minutes
Hedge Trimmer	265	.0055	--30 minutes
Garage Door Opener	350	.00024	--minute
Grinder (Food or Coffee)	150	.001	--10 minutes
Griddle	1200	.019*	--30 minutes
Hair Clipper	10	.00007	--10 minutes
Hair Dryer			
Soft Bonnet	400	.0166	--hour
Hard Bonnet	900	.0374	--hour
Hand Held	600	.0249	--hour
Hair Rollers	350	.0036	--15 minutes
Heat Lamp	250	.0104	--hour
Heating Pad	65	.0015*	--hour
Hi-Fi/Stereo	100	.00415	--hour
Hot Plate	1250	.026	--30 minutes
Humidifier	175	.02	--day
Ice Cream Freezer	130	.004	--45 minutes
Ice Crusher	120	.00041	--5 minutes
Iron	1000	.0228*	--hour

Figure 2 (CONT)

JUICER	90	.00006	--MINUTE
KNIFE SHARPENER	100	.00035	--5 MINUTES
LIGHTS*** - 100-WATT BULB	100	.0415	--10 HOURS
MAKE-UP MIRROR	25	.00026	--15 MINUTES
MICROWAVE OVEN	1500	.005	--5 MINUTES
MIXER			
HAND	100	.0021	--30 MINUTES
STANDING	150	.0031	--30 MINUTES
MOTORS****			
1/6 H.P.	170	.0004	--5 MINUTES
1/4 H.P.	250	.0006	--5 MINUTES
1/3 H.P.	330	.0008	--5 MINUTES
1/2 H.P.	500	.0012	--5 MINUTES
1 H.P.	1000	.0024	--5 MINUTES
POWER TOOLS			
DRILL (1/4 INCH)	240	.0009	--5 MINUTES
JIG SAW	370	.00128	--5 MINUTES
RADIO	75	.0031	--HOUR
RANGE			
SMALL SURFACE UNIT	1300	.015	--15 MINUTES (HIGH HEAT)
LARGE SURFACE UNIT	2400	.009	--5 MINUTES (HIGH HEAT)
OVEN (NON-SELF-CLEANING)	3200	.043*	--HOUR
(SELF-CLEANING)	3200	.034*	--HOUR
BROILER UNIT	3600	.037	--15 MINUTES
SELF-CLEANING FEATURE	4000	.15-.25*	--2 HOURS
REFRIGERATOR/FREEZER (14 CU. FT.)	330	4.16*	--MONTH
FROSTLESS	615	6.35*	--MONTH
ROASTER	1350	.034*	--HOUR
SEWING MACHINE	75	.0031	--HOUR
SHAVER	14	.00005	--5 MINUTES
SHAVING CREAM DISPENSER (HEATED)	60	.00004	--MINUTE

Figure 2 (CONT)

SLOW COOKER - LOW	75	.0031	--HOUR
HIGH	150	.0062	--HOUR
SPACE HEATER	1300	.054	--HOUR
SUMP PUMP (1/3 H.P.)	330	.0096	--HOUR
SUN LAMP	250	.0017	--10 MINUTES
TELEVISION			
BLACK & WHITE	160	.0066	--HOUR
SOLID STATE	55	.0023	--HOUR
COLOR	300	.013	--HOUR
SOLID STATE	200	.0083	--HOUR
TOASTER	1200	.0016	--2 MINUTES
TOOTHBRUSH	7	.000005	--MINUTE
TRASH COMPACTOR	400	.0014	--5 MINUTES
VACUUM CLEANER	650	.027	--HOUR
VAPORIZER			
COOL MIST	60	.0025	--HOUR
STEAM	480	.0200	--HOUR
WAFFLE IRON	1200	.02*	--30 MINUTES
WARMING TRAY	140	.006	--HOUR
WASHING MACHINE (AUTOMATIC)	500	.011	--NORMAL LOAD
WATER HEATER (QUICK RECOVERY)	4500	.10-.20	--PER PERSON/DAY
YARD OR POST LIGHTS			
175W MERCURY (BULB & BALLAST)	196	.09	--NIGHT
100W INCANDESCENT (BOTH BASED ON PHOTO-CELL CONTROL--NORMAL OPERATING HOURS FOR ONE YEAR -- 4,000)	100	.05	--NIGHT

NOTE: COSTS EXCLUDE 3% SALES TAX.

* THERMOSTATICALLY CONTROLLED. COST BASED UPON ESTIMATED PERCENTAGE OF "ON" TIME.

Figure 2 (CONT)

**ELECTRIC HEATING AND CENTRAL AIR CONDITIONING COSTS VARY WITH EACH INDIVIDUAL HOME. MANY FACTORS ARE NEEDED TO ARRIVE AT AN ACCURATE ESTIMATE: SIZE OF HOME, TYPE OF SYSTEM, AMOUNT OF INSULATION, NUMBER OF DOORS, WINDOWS, ETC.

***MANY FACTORS AFFECT LIGHTING COSTS: SIZE OF THE HOME, TYPE OF LIGHTING, ETC. BUT KEEP IN MIND -- FLUORESCENT LIGHTS ARE MORE EFFICIENT AND MORE ECONOMICAL TO OPERATE.

****MOTORS FOR FURNACES, APPLIANCES, TOOLS, PUMPS, ETC. ARE RATED BY OUTPUT HORSEPOWER (H.P.), BUT DEPENDING ON SIZE, QUALITY AND LOAD CHARACTERISTICS THE WATTAGE RATING VARIES. IN GENERAL, 1 H.P. OUTPUT EQUALS 1000 WATTS INPUT AT FULL LOAD. HOWEVER, MOTORS ARE GENERALLY SIZED TO RUN AT 70% FULL LOAD.

Figure 2 (CONT)

GAS APPLIANCES

Gas Appliance	Typical Gas Input Rating CFH	Cost	
Air Conditioners**			
Central 3 ton	80	.140*	--hour
Central 5 ton	135	.235*	--hour
Dryer			
Regular Fabrics	25	.062*	--load
Permanent Press	18	.050*	--load
Furnace**			
(January Average)	137	.073*	--hour
Outdoor Grill (Full heat)	25	.0242	--30 minutes
Range			
Surface Unit	6	.001	--5 minutes
Oven	30	.030*	--hour
Water Heater	37	.05-.10	--per person/day
Yard Light	2	.092	--day

Note: Cost includes both gas and associated electrical energy use for appliances, but excludes 3% sales tax.

* Thermostatically controlled. Cost based upon estimated percentage of "On" time.

** Natural gas heating and air conditioning costs vary with each individual home. Many factors are needed to arrive at an accurate estimate: size of home, type of system, amount of insulation, number of doors, windows, etc.

Figure 2 (CONT)

FIGURE 3

A SUMMARY OF ENERGY CONSERVATION METHODS FOR VARIOUS APPLICATIONS AND ACTIVITIES

After considering the conservation aspects of all the models and specifics of this module, one can summarize in numerical form what the better conservation activities and lifestyle approaches are that help reduce energy costs and utility bills. In general, a customer benefit from energy conservation because it:

1. Cuts down on utility and gasoline bills,
2. Helps fight pollution,
3. Saves natural gas, petroleum, and electricity now, so that such energy will be available longer.

Energy conservation methods are grouped under specific appliances and uses. The first list is for general residential and small commercial use, and the second list is for industrial and business use. However, many of the energy conservation practices for business and industry are directly applicable to the home, especially for those with electrical-electronic and audiovisual equipment.

I. GENERAL RESIDENTIAL AND SMALL COMMERCIAL CONSERVATION METHODS

A. Heating

1. In cooler months of the year, set the thermostat at 68° during the daytime, and several degrees lower at night (an extra blanket on your bed can make up the difference).
2. Set the thermostat at a comfortable temperature, then leave it alone...turning it up and down wastes energy.
3 Make sure the home has adequate insulation -- install storm windows and doors if not already in place. Three inches of insulation in attic can save as much as 25 percent on heating cost over no insulation.
4. Avoid frequent opening of outside doors. Use weatherstripping to seal air leaks around edges.
5. In winter, keep drapes open to let the sunlight in during the day; close them at night to stop cold drafts.
6. Keep the chimney damper closed when the fireplace is not in use.
7. Turn off heat vents and close off rooms that are not in use.
8. Keep filters clean...change them at least twice a year.
9. Consider a switch to solar heating in the future.
10. Remove furniture, rugs, etc., that block heating vents or radiators.
11. Place aluminum foil between radiator and exterior wall to reflect heat into the house.

B. Cooling

1. During hot months, set the temperature on "low" or keep the thermostat at 78° or more...this way less electricity will be used and occupants will feel less uncomfortable when you step outdoors.
2. In summer, close drapes to keep sunlight out to make it easier for the air conditioner to keep things cool.
3. Install a window air conditioner in the window with the most shade during the day.
4. Use heat-producing major appliances (dishwashers, dryers, ovens, etc.) during early morning or evening...not when the outside temperature is the highest.
5. Keep doors and windows closed when air conditioner is operating...and close off unused areas.
6. Keep filters clean.
7. Set the thermostat higher if the family is away most of the day and turn it off if you're going away for a weekend or longer.
8. Storm windows will help keep the cool air inside.
9. To ease the load on the air conditioning system, consider installing an attic fan to help blow out the trapped hot air.
10. Make sure sofas, bookcase, and other solid objects do not obstruct the air conditioning unit to help keep it operating efficiently.

C. Water Heating

1. Set the water heater thermostat at medium.
2. Take showers, which use less hot water than tub baths.
3. Fix leaky faucets (a drip a second wastes 700 gallons a year).
4. Don't wash dishes under running water...a dishwasher uses less hot water than hand washing.
5. Run washing machine, dryer, and dishwasher only with full loads. Wash clothes in cold water whenever possible.
6. When on vacation, set the water heater to the vacation setting. The pilot light will keep burning without using more energy to heat water. (Better still, turn the pilot light off.)
7. Don't waste hot water. For example, don't leave water running while washing hands or shaving--partially fill the basin first.

D. Lighting

1. Turn off lights when not needed.
2. Keep light bulbs and fixtures clean...brighter light may require fewer bulbs.
3. When possible, use fluorescent lamps. A 40-watt fluorescent lamp produces more light than a 100-watt incandescent bulb.
4. Install dimmer controls to save energy and add atmosphere where appropriate.
5. Use pastel walls and a light-colored interior decor, which usually requires fewer lamps.

Figure 3 (CONT)

E. Major Appliances--Kitchen Stove

1. Partially thaw frozen foods before cooking.
2. Put small pots on small burners, large ones on large burners.
3. Cover pots to avoid heat loss and reach cooking temperature quickly.
4. Use high setting on units to start, then reduce heat and food will continue to boil.
5. When cooking with water, use as little as possible so food will heat quickly.
6. When using the oven, preheat only 10 minutes...and don't peek. The oven uses less energy than the stove top because it is a confined space.
7. Avoid using aluminum foil on shelves directly under pans since it can reflect the heat away from them.
8. Cook by time and temperature. A meat thermometer can eliminate over-cooking. Precise timing eliminates heat wasted by peeking.
9. In summer, cook outdoors whenever possible to reduce heat build-up inside. Experiment with a solar cooker.
10. When using gas, regulate burners so flame tips just touch utensil bottoms.
11. A clean oven and broiler cooks more efficiently.
12. Ceramic, glass and stainless steel are best heat retainers (lower oven temperatures by 25°).

F. Major Appliances--Refrigerator/Freezer

1. Locate refrigerator out of sun and away from heat sources (stove, dishwasher, etc.)
2. Cool foods to room temperature before placing them in refrigerator.
3. Make sure gasket seals door well.
4. Defrost freezer when 1/4" of frost has built up.
5. Keep freezer full, but not overloaded: less energy is required to keep freezer cold when air can easily circulate around packages.
6. Chill food before placing it in freezer...and don't freeze too many things at once.
7. A chest freezer is more economical than an upright because when the door is opened the cold air settles on the bottom, rather than flowing onto the floor.
8. To avoid excess cold loss, open refrigerator or freezer only when necessary.
9. Check the temperature setting of your refrigerator and freezer against your appliance manual. If you store your food too cold, you will be wasting energy.
10. When preparing to go on vacation, set refrigerator at a warmer temperature and leave it fairly empty.

G. Major Appliances--Washer & Dryer

1. Keep the lint traps clean to assure top efficiency.
2. Use only when full and as cool a setting as possible (DO NOT OVERLOAD).
3. Use the water level control on your washer...small loads require less hot water.

Figure 3 (CONT)

4. Don't overdry clothes. Save ironing by hanging or folding clothes as soon as they are dry.
5. Your dryer should be located where it has easy access to clean dry air.
6. Use the free solar energy whenever possible.
7. Soak stubborn stains before washing.
8. Check type of soiling and fabric--when possible, wash clothes in cold water (except diapers).

H. Transportation

1. Reduce the amount of driving you must do...instead of five or six short trips make one well-planned and organized trip.
2. Use car pools to get to work, take kids to school, or even for shopping trips.
3. Use public transportation whenever possible.
4. Use a bicycle for short trips...uses less energy and keeps you in shape at the same time...Or walk.
5. Consider buying a smaller, more efficient car.

I. Automobile

1. Avoid jackrabbit starts and sudden stops.
2. Avoid weaving in and out of traffic; this wastes fuel and can cause needless accidents.
3. Save gasoline by turning off the car motor while waiting for someone.
4. Hold a constant driving speed when possible. Consider cruise control.
5. On hot summer days, park in the shade so the air conditioner doesn't have to work as hard. When possible, drive with the windows open.
6. Keep the car in top shape...have it tuned regularly.
7. Make sure tires are properly inflated to increase gas mileage and reduce wear.
8. If you are a two-car family, use the smaller one for running errands.
9. Change oil and oil filters every 3,000 to 6,000 miles (according to the owner's manual for particular model). A dirty engine wastes gas.
10. Improper wheel alignment cuts down on power, gas mileage, and tire mileage.

J. Appliances--General

1. Follow detergent directions carefully. Oversudsing in both dish and clothes washers uses extra energy because the equipment must work harder (try a low-suds product).
2. Use small appliances rather than large ones, when possible. For example, an electric fry pan uses less energy than an electric range burner in cooking a one-pot meal.
3. Iron all clothes at the same time to avoid reheating iron later in day or several times in one week.
4. Have gas appliances cleaned regularly so they will always operate at top efficiency.
5. Motor-driven appliances, like mixers, are particularly economical. Try hand mixing also.

Figure 3 (CONT)

K. Miscellaneous

1. Color television sets use more energy than black and white.
2. Always turn off a radio, TV, or record player when no one is watching or listening.
3. When possible, use major appliances during off-peak hours (before 8 a.m. and after 6 p.m.), when commercial and industrial use is less.
4. Keep a swimming pool in top operating condition so it doesn't waste energy.
5. Recycle aluminum, paper, and glass whenever possible.
6. Watch lawn watering...water is wasted when a lawn becomes saturated and the water starts running into the street.
7. Avoid using extension cords for major appliances and don't overload circuits. Overloading causes reduced energy efficiency.
8. Make the family aware of the energy problem and what they can do about it!

II. INDUSTRIAL AND BUSINESS

A. Heating

1. Install sufficient insulation.
2. Set the thermostat at 68° or slightly lower during the winter. (66-70° is recommended for factory areas, 72-74° for general office areas.) Avoid over-heating areas.
3. Cut heat leakage from building by using caulking and weather stripping around doors and windows.
4. Make sure heat is not left on too far into spring.
5. Reduce or turn off heat in unused areas (warehouses, docks, etc.).
6. Install automatic door closers on outside doors so they are not left open, thus heating the outdoors.
7. Reduce heating during those times when the space is unoccupied.
8. Check with equipment suppliers or qualified engineers to determine the extent to which heating, ventilating, and cooling equipment is suited for its job...is it the best?
9. Consider the practicality of infra-red heaters in high bay areas and warehouses. (It requires less fuel than other kinds of heating because it only heats solid objects in its path...not the air in between.)

B. Cooling

1. Keep the thermostat set at 72° or higher during the summer. Avoid overcooling.
2. Spray water on building roofs to reduce the effects of solar heat.
3. Close off unused areas.
4. Install automatic door closers on outside doors so they are not left open, thus cooling the outdoors.

Figure 3 (CONT)

C. Maintenance of Equipment

1. Emphasize boiler maintenance. Cleanliness improves its operation.
2. Check stack temperature to be sure of complete combustion.
3. Check the insulation on heat/cold pipes--machines will work extra hard because of leaks or a lack of proper insulation.
4. Inspect heat transfer surfaces regularly to make sure they are clean...insuring top efficiency.
5. Be on the alert for hot spots and deterioration in furnaces and pipe systems. (Air leaking into furnaces can cause large losses.)
6. Make sure furnace controls and burners are maintained for best efficiency.

D. Electricity

1. Turn off lights in empty rooms except where needed for safety and security (i.e., washroom lights).
2. Where possible, use fluorescent lighting rather than incandescent bulbs (for more lighting for less watts).
3. Turn off electrical equipment when not in actual use (e.g., typewriter while using the telephone).
4. Check and justify weekend electrical power usage.
5. Keep motor actuating controls in proper condition so that motors will not operate unnecessarily.
6. Install automatic controls for outdoor and indoor lighting so electricity is not wasted.
7. Convert to higher voltage electrical systems where practical.

E. Transportation

1. Reduce amount of driving...organize errands into one well-planned and organized trip rather than many short trips.
2. Encourage car pooling and the use of public transportation.
3. Whenever possible, ship freight by rail rather than by air... it requires less energy.
4. Keep company cars and trucks in top-shape...have them turned regularly.

F. Operation of Equipment

1. Avoid short runs on thermal process equipment when possible and shut down or idle equipment during production interruptions.
2. In many areas, energy waste is often the result of long-unquestioned plant practices that can be shown to have no effect on employee performance or product dependability... re-evaluate.
3. Schedule loads so equipment operates at top level of efficiency.

Figure 3 (CONT)

4. If possible, reschedule some electrical usage to off-peak periods when voltage remains high (before 8 a.m. or after 6 p.m.).

G. Miscellaneous

1. Recover waste heat from burner stacks and industrial processes use when possible.
2. Recycle waste materials (sawdust, oil, etc.) as supplemental fuels where possible.
3. Consider the use of heat pipes for transporting required heat or dissipating unwanted excess heat.
4. Check for accuracy of deliveries of oil, gases, etc.
5. Investigate "new" forms of energy.

These lists were developed using material from the Edmund Scientific Company Manual No. 9903.

Figure 3 (CONT)

E-OK ENERGY EFFICIENT

The N.E.W. Way to an Energy Efficient Home

Rating Sheet

STRUCTURAL ENERGY INTEGRITY ITEMS	Assigned Points	Structural Points
1. GLASS AREAS (Windows, French and Patio Doors, etc.)		
A. Percent of Glass Area to Floor Area		
Less than 8%	20	
8% to less than 10%	17	
10% to less than 12%	12	
12% to less than 15%	6	
15% to less than 20%	0	
20% to less than 25%	−15	
Greater than 25%	−30	
B. Type and Amount of Glass		
Single Glazed	0	
Storm or Double Glazed without Thermal Break		
100% of Glass Area	20	
80% to less than 100% of Glass Area	16	
60% to less than 80% of Glass Area	12	
40% to less than 60% of Glass Area	8	
20% to less than 40% of Glass Area	4	
Less than 20% of Glass Area	0	
Storm or Double Glazed with Thermal Break		
100% of Glass Area	25	
80% to less than 100% of Glass Area	20	
60% to less than 80% of Glass Area	15	
40% to less than 60% of Glass Area	10	
20% to less than 40% of Glass Area	5	
Less than 20% of Glass Area	0	
2. EXTERIOR DOORS (Other Than Glass)		
Solid or Hollow Core	0	
Insulated or Storm Door	4	
3. FLOORS		
Monolithic Slab - with no Perimeter Insulation	0	
Monolithic Slab - with R-5 Perimeter Insulation	5	
Pier & Beam with R-11 Insulation	0	
Pier & Beam with R-19 Insulation	10	
Pier & Beam with Less than R-11 Insulation	−15	
4. OUTSIDE WALLS		
Less than R-7 Insulation Installed	−20	
Less than R-11 Insulation Installed	−10	
R-11 Insulation Installed	0	
R-13 Insulation Installed	10	
R-16 Insulation Installed	15	
R-18 Insulation Installed	17	
R-23 Insulation Installed	20	
5. CEILINGS OVER CONDITIONED AREAS		
R-19 Insulation Installed	0	
R-22 Insulation Installed	12	
R-26 Insulation Installed	20	
R-30 Insulation Installed	25	
R-38 Insulation Installed	30	
6. INFILTRATION OF UNCONDITIONED AIR *		
A. Soleplate Sealed	13	
B. Wiring & Plumbing Holes and Furrdowns Sealed	10	
C. Exterior Doors & Windows Weather Stripped	3	
D. Exterior Doors & Windows Rough Opening Caulked	6	
E. Attic Access in Conditioned Space Weather Stripped	2	
F. Outside Sheathing Holes Sealed and Polyethylene Film** Installed	3	
G. Ventless or Dampered Range Hood Installed	3	
7. FIREPLACES		
No Fireplace	10	
Fireplace with Damper, Glass Screen & Make Up Air Intake	8	
Fireplace with Damper & Make Up Air Intake	5	
Fireplace with Damper	0	
Fireplace without Damper	−15	
STRUCTURAL ITEMS SUB-TOTAL Required Points	90	

MECHANICAL SYSTEM ITEMS	Assigned Points	Mechanical Points
8. ATTIC VENTILATION REQUIREMENT (See Table for Vent Area Required)		
With no Air Handler and/or Duct System in the Attic - 0.4 to 1.0 cfm per sq. ft. of Attic Floor Area "OR" With Air Handler and/or Duct System in the Attic - 1.5 to 2.0 cfm per sq. ft. of Attic Floor Area	5	
9. DUCT SYSTEM		
Attic Space R-7 Sealed Joints	0	
Attic Space R-14 Sealed Joints	5	
Unconditioned Space or Partial Conditioned	5	
None or Conditioned Space (R-4)	15	
10. AIR HANDLER AND/OR HEATING UNIT LOCATION		
Attic Space	0	
Unconditioned Space (Combustion Air to Closet puts the Unit in an Unconditioned Space)	5	
Conditioned Space	15	
11. COOLING EFFICIENCIES* (Unitary, Window Units, & Heat Pumps) at 95° Outdoor Temperature (ARI Rating or AHAM)		
A. 7.0 EER	0	
7.1 to less than 7.5	5	
7.5 to less than 8.0	10	
8.0 to less than 8.5	15	
8.5 to less than 9.0	20	
9.0 to less than 9.5	25	
9.5 or Greater EER	30	
B. Single Unit	0	
Multiple Unit	5	
12. HEATING EFFICIENCIES		
47° Outdoor Temperature		
COP .5 to less than 1.0	0	
1.0 to less than 2.0	8	
2.0 to less than 2.5	12	
2.5 to less than 3.0	16	
3.0 to less than 3.5	20	
3.5 or Greater	24	
13. WATER HEATING SYSTEM		
A. Pipe Insulation		
Lines Insulation - Non Circ. System (R-4)	5	
Not Insulated - Non Circ. System	0	
Circ. System	−50	
B. Water Heating Location		
Located within 20 ft. of Kitchen & Utility Area	3	
C. Heat Recovery or Solar Water Heating	15	
STRUCTURAL & MECHANICAL ITEMS TOTAL Required Points	135	

Remember, an E-OK home must earn at least 135 points, and a minimum of 90 of these points must be achieved in construction categories 1 through 7. If the original point rating of your present home in categories 1 through 7 has been increased by a minimum of 35 points, you still qualify for the N.E.W. program.

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*The right is reserved to test the structure for infiltration when less than one air change per hour is claimed by Point System.

**This is mandatory when a High Order Vapor Barrier is used on the outside wall.

TEXAS POWER & LIGHT COMPANY

NATIONAL ENERGY WATCH

Figure 4

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. Lighting Conservation Opportunities may be offered independently, or as part of a sequence of three modules in the following order:

Order	Module	Title of Module
1	3	Understanding Utility Bills
2	5	Lighting Conservation Opportunities
3	7	Appliance Energy Conservation Opportunities

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

MODULE DESCRIPTION:

The student will be introduced to the types of lighting fixtures used in residences and commercial buildings and will be able to compare them in terms of energy usage, light output (that is foot candles or lumens per watt), and heat output. Discussion will include the required lighting levels for certain tasks and activities, color definitions, and time elements for usage. The survey of conservation opportunities in lighting will include an analysis of cost and benefits in energy used or saved. The module concludes with suggested implementation of lighting conservation opportunities.

GOAL STATEMENT:

The objective of this module is to train secondary and post-secondary students to recognize energy-related factors in lighting, including differences in light bulbs and fixtures; and to enable the student to implement conservation techniques for lighting use in both residential and commercial settings.

READING GRADE LEVELS:

Lecture: 11
Lab : 11

SUGGESTED TEACHING TIMES:

Secondary : 1 hour
Postsecondary: 1 hour

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

UNITS:

I. Lighting Efficiency
  - A. Use Fewer Bulbs to Save Money
  - B. Lamp Life
  - C. Fluorescent Lights
  - D. Lights Produce Heat Energy

II. Estimating Lighting Requirements

III. Tips for Better Lighting Efficiency

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

TERMINOLOGY

Ballast--an electrical resistance device which maintains nearby constant current by increasing in resistance as the current increases.

British thermal unit (Btu)--a unit of heat energy equal to the heat needed to raise the temperature of one pound of air-free water from 60° to 61° F at a constant pressure of one standard atmosphere.

Cathode--the primary source of electrons in an electron tube; in directly heated tubes, the filament is the cathode.

Fluorescent--a tubular discharge lamp in which ionization of mercury vapor produces radiation that activates the fluorescent coating on the inner surface of the glass.

Footcandle--a unit of illumination, equal to the illumination of a surface, 1 square foot in area, on which there is a luminous flux of 1 lumen uniformly distributed, or equal to the illumination of a surface all points of which are at a distance of 1 foot from a uniform point source of 1 candle intensity.

Incandescent lamp--an electric lamp that produces light when a metallic filament is heated white-hot in a vacuum by passing an electric current through the filament.

Kilowatt-hour--a unit of power equal to 1000 watts; equals about 3,400 Btu.

Lumen--the unit of luminous flux, equal to the luminous flux emitted within a unit solid angle by a uniform point source of one candle intensity.

Phosphor--a luminescent material that converts part of the absorbed primary energy into emitted luminescent radiation.

Watt--unit of power equal to the rate of work represented by a current of one ampere under a pressure of one volt and taken as the standard in the U.S.: 1/746 horsepower.

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

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MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. Residences use about _______ percent of all the energy used in the United States.

   a. 16
   b. 26
   c. 36
   d. 46

2. The average home uses over _______ kilowatts of electricity each year for lighting.

   a. 100
   b. 1000
   c. 1500
   d. 2000

3. Two 60-watt bulbs give off less light than a single 100-watt bulb.

   a. true b. false

4. Fluorescent lamps are not much more efficient than incandescent lamps.

   a. true b. false

5. A 40-watt fluorescent bulb gives off more than seven times as much light as a 40-watt incandescent bulb.

   a. true b. false

6. The life of a 60-watt bulb is the same as that of a 40-watt bulb.

   a. true b. false

7. Each time a lightbulb is turned on, its life expectancy is shortened.

   a. true b. false

8. The "long-life bulbs" do not give off as much light as regular or conventional bulbs.

   a. true b. false

9. Fixtures for fluorescent lamps usually cost less than fixtures for incandescent lamps.

   a. true b. false

10. All fluorescent lamps emit a "cold" white light.

a. true b. false

11. Lights use electrical energy to make light, but most of the electrical energy goes into making heat.

a. true b. false

12. The unit of illumination is the _______:

a. footcandle
b. watt
c. ohm
d. volt

13. Stores and factories usually have illumination levels of _______ footcandles or more:

a. 10
b. 50
c. 75
d. 100

14. When one moves twice as far away from a source of light, only _______ as much light will be received:

a. 1/2
b. 3/4
c. 1/4
d. 1/8

15. Less light is required for seeing tasks, with more light needed in surrounding non-working areas.

a. true b. false

16. Longer length fluorescent lamps are more efficient.

a. true b. false

17. Heat transfer lighting fixtures can help save energy.

a. true b. false

18. Dark finishes can increase the utilization of light.

a. true b. false

19. Light finishes can decrease the utilization of light.

a. true b. false

20. Redirecting natural light with such devices as venetian blinds can save energy used for lighting.

a. true b. false

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

ANSWERS TO PRETEST

1. b. 26
2. d. 2000
3. a. true
4. b. false
5. a. true
6. b. false
7. a. true
8. a. true
9. b. false
10. b. false
11. a. true
12. a. footcandle
13. d. 100
14. c. 1/4
15. b. false
16. a. true
17. a. true
18. b. false
19. b. false
20. a. true

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

UNIT I

LIGHTING EFFICIENCY

UNIT OBJECTIVES

1. Distinguish the characteristics of incandescent and fluorescent light bulbs and fixtures.

2. Discuss the relative efficiency of incandescent, incandescent long-life, and fluorescent bulbs.

3. Discuss lamp life differences among various types of light bulbs.

4. Discuss the various types of fluorescent bulbs, their uses, and characteristics.

5. Explain the advantages and disadvantages of lamp heat produced by various bulb types.

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

UNIT I

LIGHTING EFFICIENCY

LECTURE

INTRODUCTION

The total national energy cost in the United States in 1975 was $170 billion. This amount has more than tripled in recent years. Industry in our country uses 36 percent of this energy, commerce about 11 percent, and residences about 26 percent. Of the total household energy used annually, lighting accounts for 16 percent of that usage. (See Figure 1.1) That means the average home uses over 2000 kilowatt-hours of electrical energy each year simply for lighting. A local electric plant must burn about 150 gallons of oil or over 3/4 tons of coal to generate that amount of electricity.

Light energy is important but the number of lights and the types of lighting fixtures used vs. those required for certain activities greatly affect the electricity bill and the efficiency return for the energy spent. In other words, not all light bulbs and light fixtures are equal.

ACTIVITIES

1. Acquire the present cost to the consumer of one kilowatt-hour of electricity in your area. Multiply that by 2000 to establish your annual expense for lighting. Multiply the answer by the estimated number of residents in your town. Is the figure surprising?

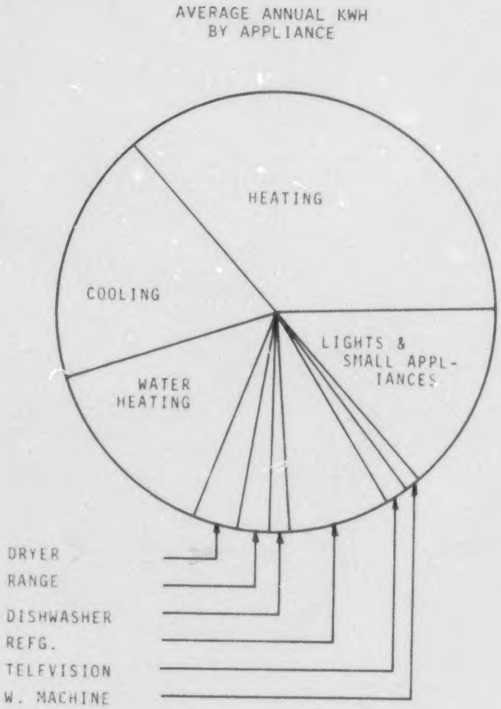
2. Find out the price paid for a barrel of crude oil by your electric plant. Multiply that by 3. (One barrel of oil contains 55 gallons. One hundred fifty gallons of oil represent approximately 3 barrels.) This is the cost per residence the electric company incurs for generating energy for lights.

What is the percentage of mark-up between the cost for the oil to the electric company and the cost to the customer for lighting energy?

3. Calculate the above figures for coal. If coal is not used in your area today to generate electricity, but is available for such use, what would the difference be in using coal vs. oil to produce the same amount of electricity?

Some lights give off much more light energy than others, even though they consume the same amount of electricity. For instance, two 60-watt bulbs actually give off less light than a single 100-watt bulb. Or one 40-watt fluorescent bulb produces almost as much light as two 100-watt incandescents while using less energy. Therefore, choice of lighting fixtures and bulbs can have a very significant effect on the electricity bill.

Figure 1.2 gives the light output of various lamps. The unit of light energy output is the lumen--the more lumens a lamp produces, the more light given. But the number of lumens is only one side of the story. Lamps are powered by electricity, so what is most important is the number of watts required to produce the desired amount of light. A measure of the efficiency of a light source is the ratio of lumens to watts. Figure 1.2 shows that small incandescent lamps are less efficient sources of light than larger lamps. Note, however, that fluorescent lamps are much more efficient than incandescent lamps. In fact, a 40-watt fluorescent bulb gives off more than seven times as much light as a 40-watt incandescent.



SOURCE: TEXAS POWER & LIGHT COMPANY

FIGURE 1.1

ENERGY EFFICIENCY OF VARIOUS LAMPS

WATTS	LUMENS	LIFE (HOURS)	(LUMENSWATT)
Incandescent Lamps			
40	435	1500	10.9
60	840	1000	14.0
75	1140	750	15.2
100	1710	750	17.1
150	2740	750	18.3
200	3940	750	19.7
Three-Way Incandescent Lamps			
50-100-150	560-1630-2190	1200	11.2-16.3-14.6
50-200-250	550-3560-4110	1200	11.0-17.8-16.4
100-200-300	1290-3440-4730	1200	12.9-17.2-15.8
Fluorescent Lamps (Cool White)			
15 (T8)	870	7500	58.0
15 (T12)	770	7500	51.3
20	1220	7500	61.0
22 (Circline)	950	7500	43.2
30	2340	15000	78.0
32 (Circline)	1750	7500	54.7
40	3120	15000	78.0
75	6200	12000	82.7

FIGURE 1.2

4. USE FEWER BULBS TO SAVE MONEY

The trend today in lighting fixtures is to use several low-wattage bulbs instead of one or two larger bulbs. Admittedly, this may make some lighting fixtures more attractive than others, but they do not use electricity as efficiently. For example, a ceiling fixture with four 40-watt bulbs, at an energy usage cost of 4 cents per kilowatt-hour, will use up to $18.69 of electricity per year if it is used 8 hours a day. On the other hand, two 60-watt bulbs are used, the lighting fixture will give off the same amount of light, but will cost only $14.02 per year to operate--a savings of $4.67.

An additional savings comes about as you replace the bulbs that burn out during the year. If the fixture is on 8 hours a day, this amounts to just under 3000 hours a year. Presently, 40-watt bulbs have an average life of 1,500 hours, compared to the 60-watt bulbs, which last only 1,000 hours. But don't let this fool you! If you use 40-watt bulbs, you would have to replace all four bulbs twice

Survey your home or school. Note the number of light bulbs in each room, the wattage of each, and whether they are of regular or long-life variety.

Are all the bulbs used at the same time?

Are there pairs of bulbs doing the job that one bulb of higher wattage could do?

Using the formula in the example, compute how much money the duplication of bulbs versus replacing the bulbs with higher wattage could be realized in one year.

Using the examples in the text and the information gathered in the exercise above, do you see places in each room where the wattage of the bulbs --not the number of bulbs-- could be reduced without losing effectiveness of that particular fixture?

What savings could you realize by replacing the wattages of these bulbs?

each year, which would mean buying eight bulbs. If you used 60-watt bulbs, even though you would have to replace them three times during the year, you would still only have to buy a total of six bulbs, which would save you the price of two bulbs each year. Using one 100-watt bulb to replace four 40-watt bulbs would save you $7.01 plus the price of four bulbs per year. Your savings would be even greater if your requirement was to burn the lights longer each day, thus shortening their life.

B. FACTORS AFFECTING BULB LIFE

The life expectancy of any bulb is shortened a little each time it is turned on. In an incandescent bulb, the initial surge of current presents quite a shock to the filament inside. Note that most bulbs seem to burn out just as they are turned on. When manufacturers calculate the average life of a bulb, they estimate how often the bulb will be turned on during its lifetime. If the bulb were only turned on once, and left on, the bulb would probably burn several times as long. On the other hand, if the lights are turned on and off dozens of times each day, the life expectancy of the bulbs will be shortened greatly because electric light is produced by heating the filament in the bulb to a high degree in order for it to glow.

One controversy which has been debated for some time is whether one should turn off a light when leaving a room for only a short while. It is argued that the amount of electricity required during the surge when a bulb is turned on is greater than the electricity used to keep it on for a short period. The point however, is not in the tiny amount of extra electricity that is consumed during the surge when the bulb

For three days, note the routine you follow when entering and leaving certain rooms in your home.

Do you consistently turn lights off when leaving a room?

How many times are lights turned OFF and ON in certain rooms?

What is the time interval beteen the number of times a light is used, then turned off, then turned on again?

Can you estimate the life expectancy of these bulbs as short, moderate, or long, based on use?

Would a change in your routine lengthen the life of these bulbs?

is turned on, but in the extent to which the life expectancy of the bulb is reduced.

If the cost to replace the bulb is weighed against the small amount of electricity consumed by being left on a few minutes, it will be noted the cost of turning on the bulb is roughly equal to the cost of electricity used in five minutes. In other words, if a bulb is turned off for less than five minutes, electricity will be saved, but in the long more money will be lost by having to replace the bulb sooner. This is one instance in which money can actually be saved by wasting a little energy.

The life of bulbs has received so much attention that manufacturers have developed "long-life bulbs." The claim is that these bulbs last several times longer than regular bulbs. It may be true that they last longer, but they do not give off as much light. The lumen output is printed on the package of each bulb. These bulbs last longer because the filaments do not get as hot, which means they do not give off as much light compared to regular bulbs.

Ironically, manufacturers charge a higher price for these long-life bulbs. Therefore, in the long run, the long-life bulb is a questionable bargain. If the bulb is needed in hard- to-reach places, such as stairwells and on high ceilings, it will be advantageous to install a long-life bulb for convenience of replacement.

As noted in Figure 1.2 fluorescent bulbs last considerably longer than incandescent types. The life expectancy of these bulbs is usually calculated for industrial users who turn on the lights in the morning and leave them on until

Discuss the pro's and con's of leaving a light on or turning it off in your particular case, based on the information you gathered in your survey above.

Bring in light bulb packages from "long-life" bulbs and regular bulbs. Compare the life expectancy and lumen output.

What have you learned?

What type do you use in your home?

Based on what you have just studied, are you getting the most for your money in using your particular bulbs?

night. Fluorescent bulbs have filaments (called cathodes) at each end of the bulb to help the flow of current through the bulb. These filaments are heated slightly, but do not produce much light. Contrary to popular belief, most modern rapid-start fluorescent tubes do not require surges of electricity when first turned on, and most tubes will not burn out faster as a result of frequent on-off-on cycles, which was a problem with older type fluorescent tubes.

C. FLUORESCENT LIGHTS

Factories, offices, and stores use fluorescent lighting for one reason--to save money! Although fluorescent fixtures typically cost two or three times as much as comparable incandescent fixtures, the savings in electricity will normally pay for the difference in less than two years. From then on fluorescent lighting costs far less than incandescent lighting. Figure 1.3 compares the advantages and disadvantages of using fluorescent lights vs. incandescent bulbs.

CHOOSING A LIGHT

	Incandescent	Fluorescent
Energy Use	Less efficient, produces more heat than light: 95% heat, 5% light.	Over 4 times as efficient as incandescent and lasts 7-10 times longer: 30% light, 70% heat.
Cost	Initial costs are less than fluorescent lighting.	Operating costs are less.
Versatility	Light can be adjusted by interchanging different wattage bulbs. Gain flexibility by using three-way bulbs and multiple switch controls.	Usually are stationary, ceiling-type fixtures that provide diffused lighting.
Best Use	For specific, close-in lighting: study, sewing room, bedroom, living room, or any area that requires light for reading and writing.	For general lighting: large work areas, bathrooms, laundry room, basement, kitchen, hallways, stairways, recreation rooms, or any large room where diffused light is required.

FIGURE 1.3

People expect fluorescent lights to be used in factories, hospitals, and industries, but they do not accept their use as readily throughout the home. There are two reasons suggested for this unacceptance: (1) fluorescent bulbs give off a "cold" white light or blue haze unlike warm yellow of incandescent; (2) the box-like shapes of fluorescent fixtures do not have the "character" of versatility in design which incandescent fixtures can have.

The light produced by a fluorescent bulb is determined primarily by the mixture of phosphors used to coat the inside of the bulb. The most common phosphor mixture is called cool white (CW), and this is the type used in most factories, offices, and stores. Colored phosphors, such as red, blue, yellow, and green, are used in many advertising signs. Other special phosphor mixes are used to make bulbs for growing plants indoors, which produce a light similar to true sunlight. There are alternatives to cool white if this makes one feel the home is like an office building.

Incandescent lamps give off a light that is somewhat yellowish in color. Putting a CW fluorescent bulb in the same room with an incandescent just accentuates this difference. Many people find the clash objectionable. They may tolerate CW bulbs in their kitchen or bathrooms, but they do not want them in their living rooms. However, there are warm white (WW) bulbs available from most electrical supply stores. These bulbs give off a yellowish light similar in color to incandescent light. WW bulbs are rarely found in department and discount stores. People seem to be unaware of their existence.

An interesting exercise might be for students to try to find these various fluorescent bulbs in your city. It may be surprising to find the limited supply of certain types, if you are able to find them at all.

What type of store handles each variety found? (Discount, electrical supply, commercial supplier, lighting shop, electrical contractor, etc.)

Manufacturers also make fluorescent lights using a deluxe phosphor mixture. Regular phosphors suffer from the fact that they do not produce a balanced spectrum of light energy. They produce light energy containing blues and greens, but lacking in reds and oranges. All colors in the light spectrum do not have to be present to make "white" light. A sampling of colors must be blended in the right proportions. Manufacturers have created cool white deluxe (CWX) and warm white deluxe (WWX) bulbs that balance the color spectrum by adding more reds and oranges. The CWX bulb still produces a light that "looks" just as white as a regular CW bulb, but if a bright red cloth is held under the two lights, a distinct difference can be noted. The red cloth will look drab and dull under the CW bulb, but it will be truly bright under the CWX bulb. The WWX bulb produces even more reds and oranges, giving the bulb a slightly pinkish appearance when placed next to a CW bulb. The "warm" light produced by the WWX bulb makes it attractive for use in the living areas of the home. Deluxe phosphors are even harder to find in stores.

Decorating with fluorescent fixtures is a harder problem to overcome because of their inherent "boxy" appearance. The most economical size fluorescent bulb to buy is the four-foot 40-watt type since this is the size used by the millions in offices and stores everywhere. Lighting fixtures using these bulbs are also quite inexpensive compared to other sizes. Most fixtures contain one, two, or four bulbs; the most common being the two-light "rapidstart" fixture. Two-light fixtures are now coming in an increasing number of styles suitable for the living areas of the home. There

Take note in your home of where you have used fluorescent lighting. Can you indicate places where you might consider replacing incandescent fixtures with fluorescent ones?

What reasons would you have for not replacing incandescent fixtures with fluorescent fixtures? (They do not go with the decor or period theme of a particular room or house, etc.)

are traditional white enamel fixtures for a kitchen, utility room, or other work area, or ones with trim that can be painted in any color desired. There are also prepainted fixtures, in bright colors, and fixtures with wood-grain trim. Office supply stores often carry a much lower selection of good-looking fluorescent fixtures than most department stores. Most fixtures have plastic covers to diffuse the light. Acrylic covers are more desirable than polystyrene because they do not yellow or crack with age. Fluorescent fixtures cost more to manufacture and therefore cost more to buy than similar incandescent fixtures. Fluorescent fixtures use less electricity, however, and will pay for themselves in a short time. A 100-watt incandescent light bulb consumes 1 kilowatt-hour of energy every 10 hours. This is the same amount of energy needed to lift a 150-pound person 17,700 feet into the air. If this amount of energy can be cut down, think of the energy savings realized.

To illustrate the savings that can be obtained with a fluorescent fixture, consider a kitchen where the light will be on for a good part of the day. For a moderately large kitchen with a dining area, an incandescent fixture having four 75-watt bulbs would be needed to provide a good working light. Assuming that the lights are on for 8 hours each day and electricity costs 4 cents per kilowatt-hour, this incandescent fixture would cost $35.04 per year to operate, plus the cost of 16 bulbs, which would bring the total cost to about $43 per year. On the other hand, a twin-light rapid-start fixture containing two 40-watt fluorescent bulbs would require only about 95 watts to run. (The fixture's ballast

Using the formula in the example, compute the possible savings in operating costs you might realize if you were to replace an incandescent fixture in your survey with a fluorescent fixture.

transformer and lamp filaments would require about 15 watts.)

The fixture would produce 37 percent more light, but would use only $11.10 of electricity during the year. The bulbs, costing only about $3 for both, would last for several years before they needed replacing, so their cost would average less than $1 per year. In this case, the cost difference amounts to about $31 per year and it would not cost much more than that to buy a good-quality fixture. Thus, after the first year, the fixture would have almost paid for itself, and from then on the saving would be $31 per year.

D. LIGHTS PRODUCE HEAT ENERGY

Lights use electrical energy to make light, but most of the electrical energy goes into making heat. The light energy that is produced in the lamp strikes objects in the room and is eventually converted into heat energy. Thus, all of the electrical energy used in lighting fixtures results in heat energy. In the winter, this is desirable because it helps to heat the home. If electric heat is used, the cost is no more. Electricity is electricity, whether heat in the home is from electric baseboard heaters or light bulbs--the costs are the same either way. If using oil or gas heat which costs less than electric heat, one can at least realize that the lights are helping to heat the home, although somewhat more expensively. In summer, however, it costs money to remove heat energy with air cooling. In this case, the extra heat energy contributed by the lights is not desirable. For each watt of lighting power, about 3.4 Btu of heat energy must be removed. A 100-watt bulb thus creates 340 Btu of heat energy.

Now that you are aware of heat given off by lights, survey the use of certain lights in your home which add unnecessarily to your air conditioning in the summer. Measure the heat one foot from the lamp, two feet, three feet.

What could you do about this to cut down on lamp heat?

Each lamp used adds heat energy, increasing the electricity bill as it lights the house--and as it heats the house. In fact, all electric appliances produce heat energy that must be removed by the air conditioner.

Of course, people should not stumble around in the house with all the lights turned off. Lights are needed in order to see what one is doing. Lights are required when reading, working, playing, and even when watching television to cut down on the glare. The trick, though, is to use lights effectively to avoid waste. This calls for a little planning and common sense. Position lamps where needed. Locate light switches conveniently. But most of all, provide the right amount of light for the type of work or recreation one is doing. Light levels that are too low will strain the eyes, and too much light simply wastes electricity.

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

UNIT II

ESTIMATING LIGHTING REQUIREMENTS

UNIT OBJECTIVE

Calculate lumen requirements and light bulb recommendations for various locations or task activities.

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

UNIT II

ESTIMATING LIGHTING REQUIREMENTS

LECTURE | ACTIVITIES

The unit of illumination is the footcandle, which originated as the amount of light falling on a surface placed one foot away from a lighted candle. In recent years this unit has been replaced by the candela, but most literature still uses the footcandle. A light bulb produces light energy that is measured in lumens. If one lumen of this light energy falls on one square foot of surface, the surface is said to have an illumination level of one footcandle.

Stores, factories, and office buildings typically have illumination levels of 100 footcandles or more and have drawn much criticism lately because that may be more light than necessary. Figure 2.1 lists the typical amount of light needed in various rooms for performing different tasks.

RECOMMENDED LIGHTING LEVELS

LOCATION OR TASK	FOOT-CANDLES
bathroom, general area	5
bathroom, at mirror	40
bedroom, general area	5
bedroom, at mirror	20
church, auditorium	10
classroom	30
closet	20
dining room	5
garage, storage area	10
garage, work area	50
hallway or corridor	5
ironing	100
kitchen, general area	10
kitchen, work area	40
living room, general area	20
office, service area	10
office, file work	30
office, close visual work	50
reading, short periods	20
reading, long periods	40
sewing, light fabrics	40
sewing, dark fabrics	120
stairway	10
utility room	10
writing	20

FIGURE 2.1

The number of light bulbs needed to achieve these general lighting levels varies with the type of fixture used and the coloring of the walls, floors, draperies, and furniture in the room. A formula to use for finding the number of light bulbs needed in an average room is:

$$\text{number of bulbs} = \frac{2 \times \text{foot-candles} \times \text{floor area}}{\text{lumens per bulb}}$$

For example, in a 12- by 15-foot living room, the floor area would be 180 square feet. Figure 2.1 shows the desired illumination level is 20 foot-candles. If 100-watt incandescent bulbs are used, each bulb would emit 1,710 lumens. The number of the bulbs required in this case would then be

$$\frac{2 \times 20 \times 180}{1{,}710} = 4.2 \text{ bulbs}$$

Therefore, the need would be approximately four 100-watt bulbs. The lighting requirements depend upon the type of fixture, the placement of the lamps in the room, and room colors. If the bulbs were covered with a lamp shade, and the floors and furniture were medium to dark colors, two or three times as many bulbs may be needed to achieve a satisfactory lighting level. Light colors will increase the lighting level by reflecting and bouncing light around the room; dark colors will absorb light.

If one work near the lamp, the general level of light in the room will not be important. For example, one might be using a floor lamp or desk lamp for reading or sewing. The light level obtained directly from a bare light bulb is obtained from the formula:

Pick any area in your home and compute the recommended lumen requirements for that area based on the type of activity which takes place there.

Is the present lighting adequate or unnessary for the activity?

Discuss the measures you could take to correct the situation.

$$\text{footcandles} = \frac{\text{lumens per bulb}}{12 \times \text{distance squared}}$$

For example, if one is reading a newspaper located 3 feet from a 100-watt bulb (1710 lumens), the light level would be

$$\frac{1710}{12 \times 3 \times 3} = 15.8 \text{ foot-candles}$$

Normally, the lamp would have a shade that would help direct the light, so the amount of light falling on the newspaper would be increased to about 20 or 30 foot-candles.

Note that the amount of light striking a surface decreases as the square of the distance; that is, the distance times itself. This means that when one moves twice as far away from a source of light, only one-fourth as much light will be received. Similarly, if one is only half as far away, four times as much light would be received. To put this fact to work for you, consider a 30-inch-high table standing below a flushmounted ceiling fixture in a room with an 8-foot ceiling. In this common situation, the light level on the table top will be about twice as much as at floor level without the table.

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

UNIT III

TIPS FOR BETTER LIGHTING EFFICIENCY

UNIT OBJECTIVE

Discuss lighting conservation tips and apply them to actual situations.

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

UNIT III

TIPS FOR BETTER LIGHTING EFFICIENCY

LECTURE	ACTIVITIES
The following Institute of Environmental Studies recommendations for the better utilization of energy expected for lighting is a generally accepted standard for lighting design and use. It will serve as a capsulization of tips on lighting the student will find helpful.	Discuss each of these items as they pertain to examples students can give for their particular situations.
1. Design lighting for expected activity. More light is required for seeing tasks, with less light needed in surrounding non-working areas.	Differentiate between household use and commercial use.
2. Design with effective lighting fixtures, and windows and skylights. Electric lighting and window lighting effectiveness depends on how well the light provided ennances the visibility of visual tasks. Light from either source, if not controlled, can reduce visibility by producing veiling reflections (reflections which will partially hide the details of a task and lower the task contrast) and disability glare (light scattered in the eyes producing a haze to look through --such as that experienced with oncoming headlights at night).	
It has been found, for example, that lighting from the side by electric lights of specific design can enhance task visibility by reducing veiling reflections. Conversely, a heavy concentration of light from overhead and forward of the task can produce a high degree of veiling reflections.	

Well-shielded (low brightness) luminaires can eliminate disability glare.

3. Use efficient light sources (higher lumen/watt output).

a. For incandescent lamps, higher wattage lamps are more efficient.

40-watt general service produces about 11 lumens/watt input.

100-watt general service produces about 22 lumens/watt input.

Therefore in design consider use of fewer and higher wattage lamps.

b. For fluorescent lamps, longer length lamps are more efficient.

Two 24-inch cool white lamps produce 50 lumens/watt.

Two 48-inch cool white lamps produce 67 lumens/watt.

Two 96-inch (800MA) cool white lamps produce 73 lumens/watt.

c. For HID lamps, (high pressures sodium and metal halide) higher wattage lamps are more efficient.

400-watt phosphor coated mercury produces about 46 lumens/watt.

1000-watt phosphor coated mercury produces about 49 lumens/watt.

400-watt metal halide produces about 74 lumens/watt.

1000-watt metal halide produces about 85 lumens/watt.

400-watt high pressure sodium produces about 100 lumens/watt.

d. For overall design, consideration should be given to the use of the more efficient sources such as fluorescent and HID.

4. Use more efficient bulbs. More efficient bulbs not only use energy more efficiently but also can reduce the user's lighting costs. For example, incandescent indirect bulbs may require a load of 10 watts per square foot of floor area to produce a 50 footcandle level, but direct fluorescent lights may only require a load of about 2.5 watts per square foot.

5. Use heat transfer fixtures. By using bulbs with air or water heat transfer capabilities, heat from fixtures can be exhausted before entering an occupied space in warm weather or conversely the heat can be utilized in the occupied space in cold weather. By integrating the lighting and air conditioning systems less room heating and cooling load should be required.

6. Use lighter finishes on ceilings, walls, floor and furnishings. Light finishes can increase the utilization of light. For example, by repainting ceiling, walls and floor and refinishing furniture, the average illumination level can be increased from less than 100 footcandles to over 40 footcandles.

In selecting light finishes, reflectances should be in the following range:

Ceiling Finishes..	80-92 percent
Walls	40-60 percent
Furniture.........	26-44 percent
Office Machines & Equipment.......	26-44 percent
Floors............	21-39 percent

The upper limits have been selected to avoid excessively bright surfaces which can be uncomfortable or reduce visibility by producing disability glare.

7. Use efficient incandescent lamps. Higher wattage General Service lamps are more efficient than the lower wattage lamps. Therefore, using fewer higher wattage lamps may save power. For example, one 100-watt lamp produces more light than two 60-watt lamps (1740 lumens vs. 2 X 860 = 1720 lumens).

a. For the same wattage, General Service lamps (750 to 1000 hours life) are more efficient than Extended Service lamps (2500 hours life). For example, a 100-watt General Service lamp produces 17.4 lumens/watt input while a 100-watt Extended Service lamp 14.8 lumens/watt input. For equal lighting results in this case, 17.5 percent more lamps and power are required when using the Extended Service lamps.

b. Extended Service lamps are used where maintenance labor costs are high or where lamps are in inaccessible locations.

8. Turn off lights when not needed. When a working or living space is empty, secure and not used for display or observation, there is no need for lighting. In this case it is always more economical to turn off incandescent lighting and, where off-time is more than a few minutes, fluorescent and high-intensity discharge lighting should be turned off.

In areas where adequate daylighting is possible, photoelectric control systems can be utilized to turn off the electric lighting.

9. Control window brightness. The requirements for good lighting design can be achieved by skillful application of daylighting techniques. These techniques include:

a. Redirecting available light for better interior distribution and utilization, such as with venetian blinds.

b. Limiting the brightness of fenestration to within comfortable limits (the same criteria as used for electric sources) by using devices such as: shades, screens, blinds, and low transmission glasses.

c. Controlling heat producing radiation entering a space by utilizing such means as reflective glass coatings and sun screening to reduce air conditioning requirements.

10. Utilize daylighting as practicable.

11. Keep lighting equipment clean and in good working condition. Studies have shown that good lighting maintenance procedures provide better utilization of the lighting system.

If better maintenance procedures are followed, it may be possible to reduce the wattage of incandescent lamps in a given system as long as adequate illumination is still maintained.

In designing new lighting systems more attention should be given to maintenance procedures and the consumer (tenant or owner) should be aware of the maintenance procedures considered in the design.

12. Be cognizant of planned operation and maintenance procedures. For building owners' and tenants' information, as consumers, all illuminated spaces should have a set of instructions covering the operation and maintenance of the lighting (electric or daylight), both for maximum utilization of power and for economic considerations.

MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

POSTTEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. A 40-watt fluorescent bulb gives off the same amount of light as a 40-watt incandescent bulb.

   a. true b. false

2. Incandescent lampts are less efficient than fluorescent lamps.

   a. true b. false

3. It is obvious that two 60-watt bulbs give off more light than a single 100-watt bulb.

   a. true b. false

4. Over 2000 kilowatts of electricity is used each year, for lighting, in the average home.

   a. true b. false

5. In the United States, residences use about _______ percent of all the energy used in the United States.

   a. 16
   b. 26
   c. 36
   d. 46

6. Very little of the electrical energy used by incandescent lights goes into making heat.

   a. true b. false

7. Not all fluorescent lamps give off a "cold" white light.

   a. true b. false

8. Usually, the fixture for fluorescent lamps cost more than fixtures for incandescent lamps.

   a. true b. false

9. It is true that the "long-life" bulbs give off more light than regular or conventional bulbs.

   a. true b. false

10. The life expectancy of a light bulb is increased by turning it on and off as little as possible.

    a. true b. false

11. The life of a 60-watt bulb is not the same as that of a 40-watt bulb.

    a. true b. false

12. Shorter length fluorescent lamps are more efficient.

    a. true b. false

13. More light is required for working areas, with less light needed in surrounding non-working areas.

    a. true b. false

14. When one moves twice as far away from a source of light, only 1/4 as much light will be received.

    a. true b. false

15. Stores and factories usually have illumination levels of less than 75 footcandles.

    a. true b. false

16. The unit of illumination is the footwatt.

    a. true b. false

17. Redirecting natural light does little in saving energy used for lighting.

    a. true b. false

18. It is true that light colored finishes can increase the utilization of light.

    a. true b. false

19. It is true that dark finishes can decrease the utilization of light.

    a. true b. false

20. It is really a waste of energy to buy heat transfer lighting fixtures.

    a. true b. false

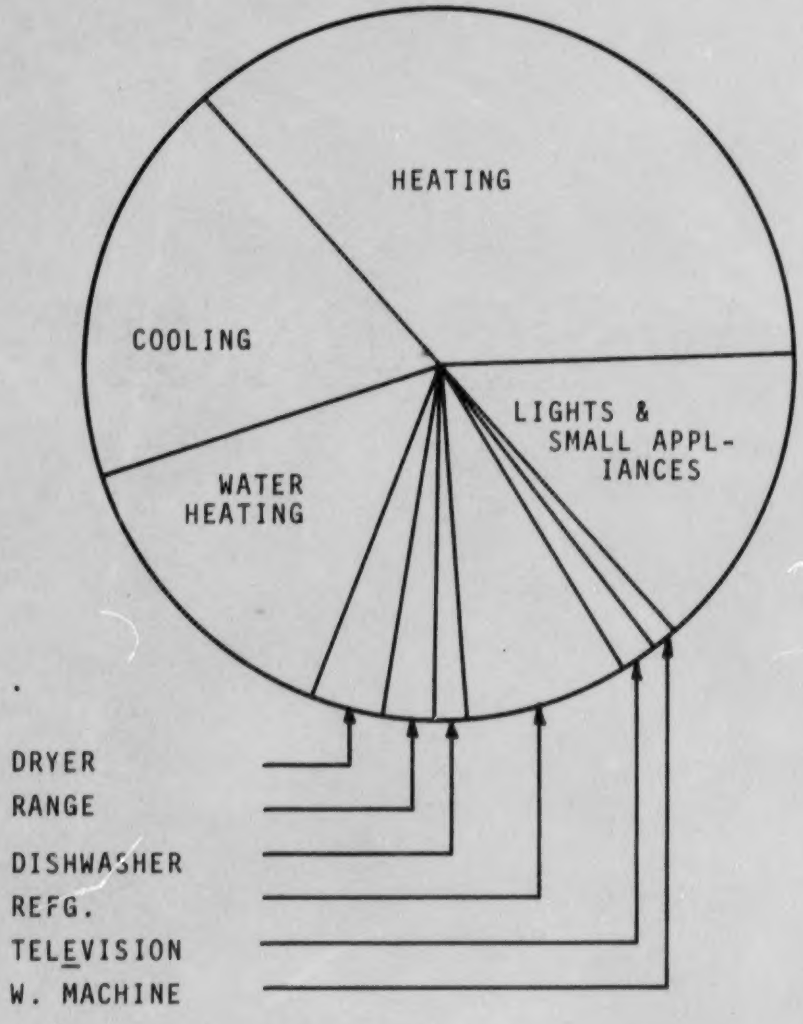
MODULE V

LIGHTING CONSERVATION OPPORTUNITIES

ANSWERS TO POSTTEST

1. b. false
2. a. true
3. b. false
4. a. true
5. b. 26
6. b. false
7. a. true
8. a. true
9. b. false
10. a. true
11. a. true
12. b. false
13. a. true
14. a. true
15. b. false
16. b. false
17. b. false
18. a. true
19. a. true
20. b. false

AVERAGE ANNUAL KWH
BY APPLIANCE



SOURCE: TEXAS POWER & LIGHT COMPANY

FIGURE 1.1

ENERGY EFFICIENCY OF VARIOUS LAMPS

WATTS	LUMENS	LIFE (HOURS)	(LUMENSWATT)
Incandescent Lamps			
40	435	1500	10.9
60	840	1000	14.0
75	1140	750	15.2
100	1710	750	17.1
150	2740	750	18.3
200	3940	750	19.7
Three-Way Incandescent Lamps			
50-100-150	560-1630-2190	1200	11.2-16.3-14.6
50-200-250	550-3560-4110	1200	11.0-17.8-16.4
100-200-300	1290-3440-4730	1200	12.9-17.2-15.8
Fluorescent Lamps (Cool White)			
15 (T8)	870	7500	58.0
15 (T12)	770	7500	51.3
20	1220	7500	61.0
22 (Circline)	950	7500	43.2
30	2340	15000	78.0
32 (Circline)	1750	7500	54.7
40	3120	15000	78.0
75	6200	12000	82.7

FIGURE 1.2

CHOOSING A LIGHT

	Incandescent	Fluorescent
Energy Use	Less efficient, produces more heat than light: 95% heat, 5% light.	Over 4 times as efficient as incandescent and lasts 7-10 times longer: 30% light, 70% heat.
Cost	Initial costs are less than fluorescent lighting.	Operating costs are less.
Versatility	Light can be adjusted by interchanging different wattage bulbs. Gain flexibility by using three-way bulbs and multiple switch controls.	Usually are stationary, ceiling-type fixtures that provide diffused lighting.
Best Use	For specific, close-in lighting: study, sewing room, bedroom, living room, or any area that requires light for reading and writing.	For general lighting: large work areas, bathrooms, laundry room, basement, kitchen, hallways, stairways, recreation rooms, or any large room where diffused light is required.

FIGURE 1.3

RECOMMENDED LIGHTING LEVELS

LOCATION OR TASK	FOOT-CANDLES
bathroom, general area	5
bathroom, at mirror	40
bedroom, general area	5
bedroom, at mirror	20
church, auditorium	10
classroom	30
closet	20
dining room	5
garage, storage area	10
garage, work area	50
hallway or corridor	5
ironing	100
kitchen, general area	10
kitchen, work area	40
living room, general area	20
office, service area	10
office, file work	30
office, close visual work	50
reading, short periods	20
reading, long periods	40
sewing, light fabrics	40
sewing, dark fabrics	120
stairway	10
utility room	10
writing	20

FIGURE 2.1

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. Water Heating Conservation Opportunities may be offered by itself or as a part of a sequence of three modules in the following order:

Order	Module	Title of Module
1	3	Understanding Utility Bills
2	6	Water Heating Conservation Opportunities
3	7	Appliance Energy Conservation Opportunities

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

MODULE DESCRIPTION:

The types of water heaters are discussed and compared to ascertain the operating characteristics and the efficiency of each from the standpoint of input energy, heat loss, and recovery capacity. Water temperature variances for specific household uses are discussed for appliances such as dishwashers and clothes washers. Personal hygiene in using showers versus baths, water use habits for shaving, rinsing items, and related activities are discussed for various family sizes. Water use and control for food preparation and kitchen use are outlined. Flow rates for water consumption are explained and costs versus benefit analysis in hot water conservation opportunities are surveyed.

In addition to heating water, cold water use and conservation activities are discussed as indirect and direct energy users in the home and at the power plant. Finally, solar water heating is discussed as a potential alternative to using conventional energy to heat water in the home.

GOAL STATEMENT:

The objective of this module is to train secondary and postsecondary students in the recognition, implementation, and utilization of energy consumption and possible conservation in residential water heating and domestic hot water use.

READING GRADE LEVELS:

Lecture: 10
Lab : 8

SUGGESTED TEACHING TIMES:

Secondary : 2 hours
Postsecondary: 2 hours

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

UNITS:

- I. Domestic Hot Water Use
  - A. Hot Water Heaters
  - B. Energy Saving Tips for Hot Water Use
    - (1) General
    - (2) Personal Hygiene
    - (3) Kitchen and Laundry
- II. Water Conservation
- III. Consider Solar Water Heating
  - A. Solar Energy Systems
  - B. Kinds of Systems
  - C. The Final Decision

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

TERMINOLOGY

Auxiliary heater--a conventional hot water heater that acts as a back-up to being the water up to temperature on cloudy days. It is used in support of a solar water heating system.

Closed loop system--a solar energy system which circulates a liquid continuously between a collector and a storage tank utilizing a heat exchanger and a treated water solution.

Flue--a tube that allows gases formed during the burning process to escape.

Grey water--recirculated, non-potable water.

Heat exchanger--also called a heat chamber--that part of the furnance or solar energy system that houses the burners or the hating elements. Air or water is warmed as it passes through the heat exchanger.

Insulation--material that does not readily conduct heat energy.

Kilowatt-hour--a unit of power equal to 1000 watts; equals about 3,400 Btu.

Open-loop system--a solar energy system which heats water through the collector and circulators it through a storage tank.

Potable water--water that is suitable for drinking.

Solar energy--pertaining to the heating property of the sun.

Thermosyphon--a solar water heating system which circulates water from the collector to the storage tank by hot water rising, being pushed by the cold water, thus creating a circulation.

Volt--a unit of electrical potential difference and electromotive force equal to the difference of potential between two points in a conducting wire carrying a constant current of one ampere when the power dissipated between these two points is equal to one watt and equivalent to the potential difference across a resistance of one ohm when one ampere is flowing through it.

Watt--a unit of power equal to the rate of work represented by a current of one ampere under a pressure of one volt and taken as the standard in the U.S.: 1/746 horsepower.

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

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MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. Energy used to heat water for domestic use is the _______ largest household use of gas, electricity, and oil.

   a. 2nd
   b. 3rd
   c. 4th
   d. 5th

2. The cost of heated water constitutes approximately _______ percent of the annual home energy bill.

   a. 15
   b. 25
   c. 45
   d. 55

3. The average American family of four uses approximately _______ gallons of water a day for indoor use.

   a. 100
   b. 200
   c. 300
   d. 400

4. The average American family of four uses approximately _______ gallons of heated water a day for indoor use.

   a. 15
   b. 25
   c. 55
   d. 75

5. Water heater flues _______ be capped.

   a. should   b. should not

6. An electric water heater _______ heat water as quickly as gas.

   a. can   b. cannot

7. An electric water heater has some advantages over a gas water heater.

   a. true   b. false

8. An electric water heater is less expensive to operate than a gas water heater.

   a. true b. false

9. An electric water heater requires a flue pipe.

   a. true b. false

10. Most electric water heaters use 240 volts.

    a. true b. false

11. In a typical household, heat loss through the tank walls accounts for approximately _______ percent of the energy consumed for heating the water.

    a. 10
    b. 15
    c. 25
    d. 50

12. Hot water service pipes should be wrapped with V_2 inch foam or fiberglass insulation.

    a. true b. false

13. It is of no advantage to place the water heater near the major hot water users in the home.

    a. true b. false

14. A single handle washerless valve faucet can save you water.

    a. true b. false

15. Bathing in a shower generally requires less water than bathing in a tub.

    a. true b. false

16. _______ percent of household water is used in the kitchen and laundry.

    a. 5
    b. 10
    c. 25
    d. 50

17. The major user of cold water in the home is the _______:

    a. kitchen
    b. laundry
    c. water heater
    d. toilet

18. Garbage disposals are economical and practical to operate.

    a. true b. false

19. An aerator installed on the kitchen faucet _______ the volume of water flowing:

    a. increases b. decreases

20. You can save water by watering outdoor plants during the middle of the day rather than early in the morning or late at night.

    a. true b. false

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

ANSWERS TO PRETEST

1. a. 2nd
2. b. 25
3. c. 300
4. d. 75
5. a. should
6. b. cannot
7. a. true
8. b. false
9. b. false
10. a. true
11. c. 25
12. a. true
13. b. false
14. a. true
15. a. true
16. c. 25
17. d. toilet
18. b. false
19. a. decreases
20. b. false

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

UNIT I

DOMESTIC HOT WATER USE

UNIT OBJECTIVES

1. Appreciate and discuss the substantial amount of energy required to supply hot water for domestic use.
2. Recognize the characteristics and operational features of various electric and gas water heaters.
3. Discuss the reasons for and compute the operational cost differences between gas and electric water heaters.
4. Discuss routine maintenance steps the customer can perform to increase the efficiency of the home water heater.
5. Formulate a philosophy of energy conservation in using hot water for personal hygiene, kitchen, and laundry use.

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

UNIT I

DOMESTIC HOT WATER USE

LECTURE

ACTIVITIES

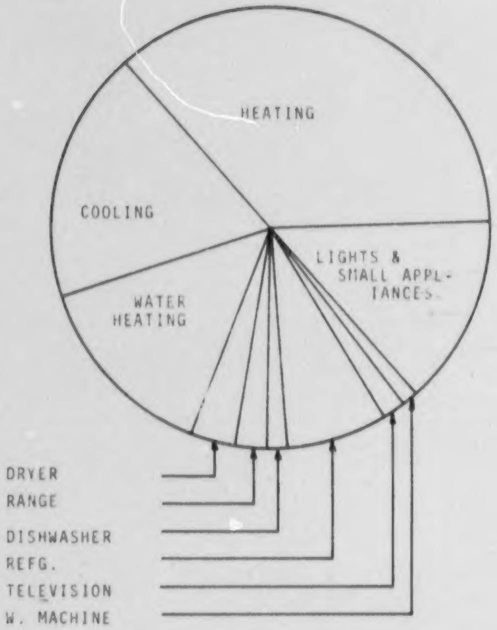
INTRODUCTION

Water has been considered a free resource with unlimited supply and availability in this country. This attitude, however, is changing somewhat. Environmental considerations now restrict the building of dams, water reserves, and sewage plants. Population is shifting more to the Sunbelt states where water can be relatively scarce. This requires new water supplies as well as energy to treat the water before using, to treat the sewage after using, and to pump and transport water for servicing homes and businesses. Therefore, water used in the home represents an expenditure of considerable energy, either directly or indirectly, and should be used conservatively.

The most direct expenditure of energy in water use is for heating water. If a person conserves household water, there will be a small savings realized on the monthly water bill; but if a customer uses less hot water, a substantial savings on the gas or electric bill can be achieved.

Energy used to heat water for domestic use is the second largest household use of gas, electricity, and oil, following space heating and cooling requirements. The cost of heating water constitutes approximately 25% of the annual home energy bill. (Figure 1.1) Conservation measures can be taken without sacrificing domestic comfort or convenience, and at minimal expense. This module will explore the conservation opportunities for using hot water in the home and the benefits to be gained. It will conclude by discussing general water saving measures related to cold water use.

AVERAGE ANNUAL KWH
BY APPLIANCE

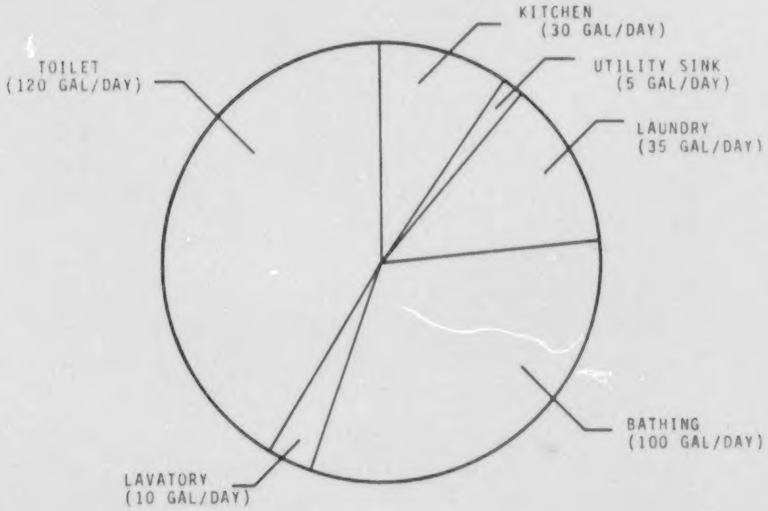


SOURCE: TEXAS POWER & LIGHT COMPANY

FIGURE 1.1

The average American family of four uses approximately 300 gallons of water a day for indoor use. Figure 1.2 breaks down this water consumption as follows: toilets consume 40%; lavatories, 3%; bathing, 33%; laundry, 12%; utility sink, 2%; and kitchen, 10%.

WATER CONSUMPTION IN A TYPICAL HOME (FAMILY OF FOUR)



SOURCE: EUGENE ECCLI, _LOW-COST, ENERGY-EFFICIENT SHELTER FOR THE OWNER AND BUILDER_, 1976.

FIGURE 1.2

Of this daily amount, about 75 gallons is heated water. Therefore, of the 110,000 gallons of water used annually, 27,500 gallons are hot, which require 23 to 41 million Btu of energy to heat. This amounts to 180 gallons of oil, or 6,000 KWH of electricity annually at a cost to the customer of about $120 for oil or gas, and over $200 for electricity. This cost is above the cost for the water itself which can be $75 to $100 annually. The actual water consumption for the home varies widely, depending on living habits of the users and the efficiency of fixtures and appliances. To save energy and cut down on hot water costs, consider the heater tank in terms of its size and location.

A. WATER HEATER

The domestic water heater is the source for supplying heated water in the home. Gas water heaters and electric water heaters operate much like a gas or electric furnace. If checked periodically and maintained properly they will operate efficiently, giving the customer the most hot water for energy spent.

The gas water heater is a tank of various gallon capacities, with insulated sides, and a flue through the center of the unit vented to the outside as shown in Figure 1.3.

THE GAS WATER HEATER

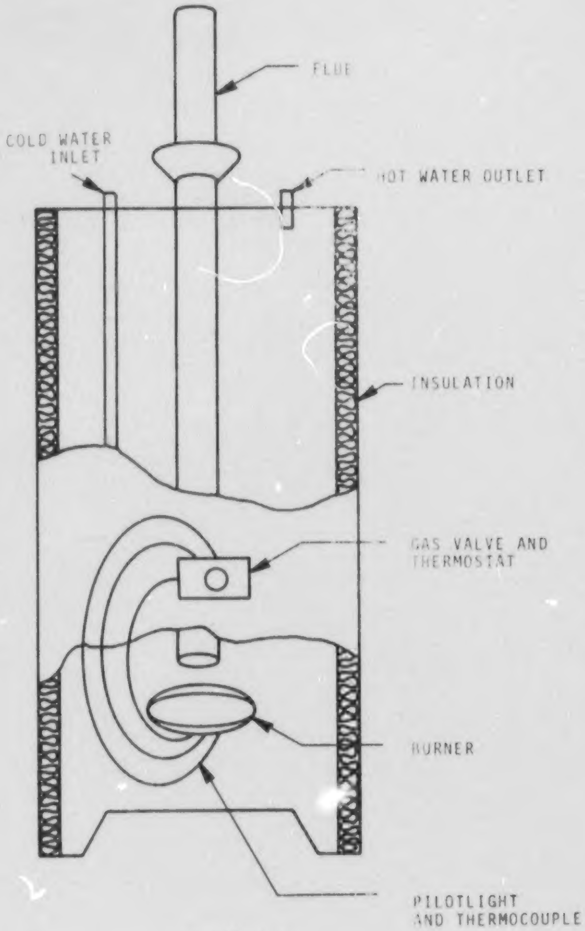

FLUE
COLD WATER INLET
HOT WATER OUTLET
INSULATION
GAS VALVE AND THERMOSTAT
BURNER
PILOTLIGHT AND THERMOCOUPLE

FIGURE 1.3

Heat is provided by a circular burner located at the bottom of the tank. The gas valve and thermostat are usually combined in one assembly, and located on the outside front of the tank. This allows gas to be fed to the burner and shut off when the water has reached a certain temperature. A thermocouple acts as a safety device which shuts off the gas valve if the pilot light should go out. The tank is often glass-lined and retains heat similar to a thermos bottle. The amount of insulation varies from 1 1/2 inches to about 3 inches. Becoming acquainted with these features and paying close attention to their proper operation helps dispel the mystery and helplessness some people have if something goes wrong with the hot water heater.

The consumer should periodically check the tank for cracks, leaks, and proper gas, water, and flue/pipe connections. Any means by which heat or hot water can escape constitutes a waste of energy. Check the burners for cracks or breaks and clean them for proper burning. Make sure the flue is free from obstructions and has a rain cap. Birds often build nests in warm flues which are not capped. Once a month, flush the tank to rid chemical impurity build-up and rust. Clean dust and grease build-up from the thermostat and valve housing and connecting wires. Additional measures will be discussed later in this module.

The construction of electric water heaters, unlike gas heaters, vary depending on the type and placement of the heating elements. The heating elements of electric heaters may be wrapped around the tank or submerged within, may have one heating element or two elements, and may require 120 volts or 240 volts for operation. The volume size of an electric water heater must be larger than a gas heater for comparable service. For instance, the average gas hot water tank size for a family of four is 30 gallons. The required size of an electric water heater for the same family is 50 gallons. The reason for this is that an electric water heater cannot heat water as quickly as gas, and therefore requires a larger initial heated volume.

There are advantages to an electric water heater, however. It can be completely surrounded by insulation instead of insulating only the sides as with a gas heater. An electric unit requires no flue pipe, allowing placement anywhere in the home. Operating costs, however, are much greater for an electric water heater than for its gas counterpart.

Most electric water heaters use 240 volts, with only the smaller ones using 120 volts. Dual heating element models provide more hot water than single-element ones but cost more in initial price and operating costs. In a dual element model, the main heating element is located near the bottom where cold water enters the unit. As hot water is drawn from the tank, cold water enters the bottom of the tank and activates the bottom heating element, as shown in Figure 1.4.

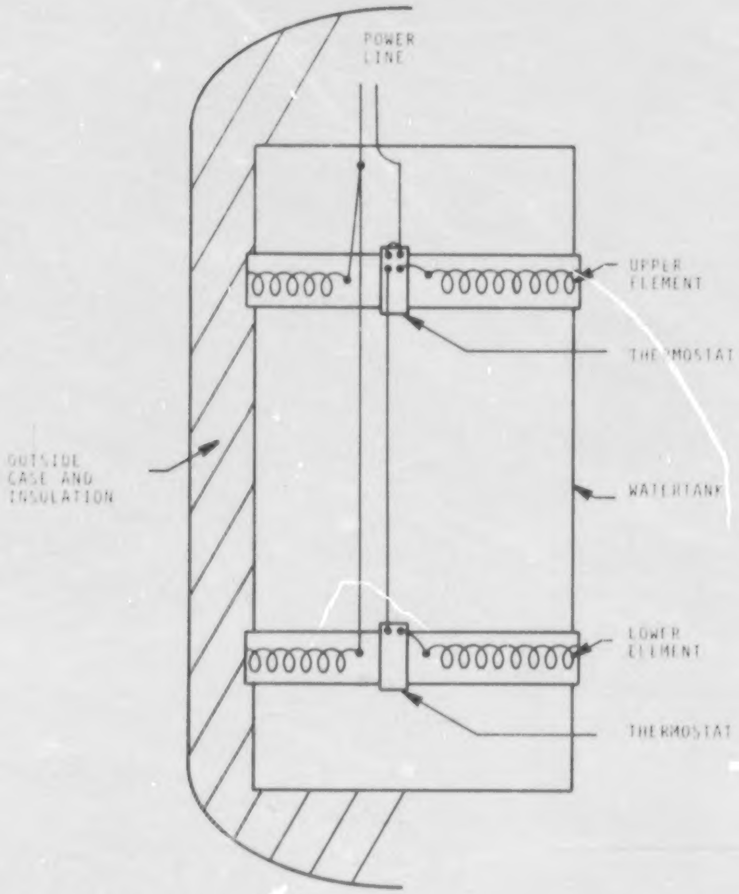

POWER LINE
UPPER ELEMENT
THERMOSTAT
OUTSIDE CASE AND INSULATION
WATERTANK
LOWER ELEMENT
THERMOSTAT

FIGURE 1.4

For normal use, this is the only heating element needed to heat the water. If there is a great demand, the upper element as well as the bottom element will heat. The heating elements in Figure 1.4 are belted types, which wrap around the outside of the tank. The insulation and outside casing cover the heating belts. Figure 1.5 shows an electric water heater which uses two submersible heating elements. The principle is the same as with the belted heating elements in Figure 1.4

THE SUBMERSIBLE-ELEMENT WATER HEATER

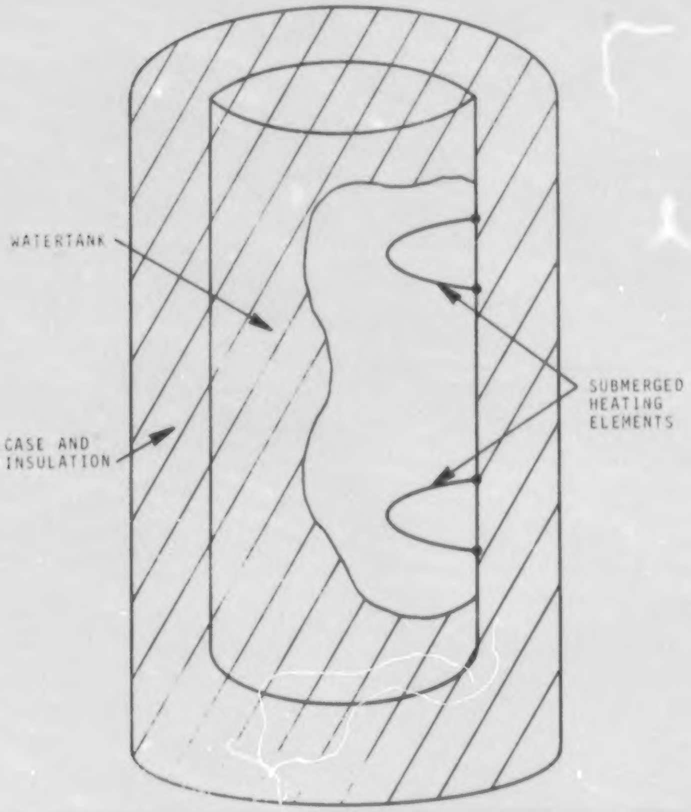


FIGURE 1.5

Each of the two elements has its own thermostat to control the temperature of the water. The top element heats first and remains on until the required temperature is reached by the top thermostat. The top thermostat then turns off its heating element and turns on the bottom element. Each of the two elements may be the same wattage rating or may differ, such as 4,500 watts for the bottom element and 2,500 watts for the top element. Quick-recovery water heaters have higher wattage ratings than regular models, use more energy, and require heavier gauge wire to operate.

Routine maintenance is important on an electric hot water heater because cracks in the outer case can allow water to come in contact with the heating element. This provides a path for electricity to ground, which causes an unnecessary drain on the electricity.

In addition to routine maintenance of water heaters, other measures can be taken to increase the efficiency of the water heater itself. In a typical household, heat loss through the tank walls account for approximately 25 percent of the energy consumed for heating the water. Additional losses occur through uninsulated service pipes. The burners and heating elements in the tank account for a great loss in efficiency since a gas or oil burner is only 50-60 percent efficient in its configuration, and an electric heating element is only 33-40 percent efficient.

To help cut down on these heating losses, consider wrapping the water tank with a 2- to 3-inch batt of insulation. Place the insulation with the vapor barrier away from the tank. On an electric heater, cover the top as well as the sides and secure with duct tape. On a gas or oil heater, the top cannot be covered because of water connections and the flue. There are also hot water blanket kits available from hardware and major catalog order stores for $20 to $25. This can cut heat loss and save about 400 KHW/year for electric heaters, and about 3,600 CCF gas/year.

Hot water service pipes should be wrapped with 1/2 inch foam or fiberglass insulation. This is easy in new construction but may be impractical in a standing structure. These two steps, however, can save 10-20 percent a year in hot water fuel bills.

Place the water heater near the major hot water users in the home and in a warm place. This will eliminate water traveling long distances and cooling in the pipes.

If the front of the water heater is removed for servicing or repair, be sure the insulation is repacked around the elements and the panel is replaced securely. This will eliminate air leakage.

Consider using a timer on an electric heater, especially if no one is home during the day. This will require the heater to be turned on only when needed, or during the peak periods of operation. Turn off the heater when going away for a weekend or vacation. It takes only three to five hours to totally heat a tank of water from cold tap water.

When selecting a water heater, be sure it is sized properly for the family needs. A typical family of four requires a 30-gallon gas or oil heater or a 50-gallon electric heater. It should have a thick insulation and a recovery rate of at least 75%, which means the tank will reheat 30 gallons in one hour.

Set the thermostat on 120° at 125° instead of 150°. This simple step can save as much as 25 percent of the fuel used annually to heat water and will not cause any appreciable inconvenience to the users. This may be too low a setting for some families and, therefore, should be tried. Remember, the higher the setting, the more fuel will be used.

Another means of reducing the amount of energy used to heat water is to install a heat recovery system on the central air conditioner, heat pump, or fireplace. The unit is a heat exchanger with a circulation pump. The pump uses waste heat from the condenser fan on the air conditioner or heat pump, and transfers it to the water tank where it is stored. This acts as a pre-heat or auxiliary heat for conventional units and deserves consideration in those areas where air conditioners are used throughout most of the year and where electric water heaters must be used.

B. ENERGY-SAVING TIPS FOR HOT WATER USE

1. General

a. Develop an energy-conscious attitude toward using hot water--the most effective means of conserving energy used for water heating is toward hot water use. This may require breaking some habits, but it will not place an unnecessary strain on hot water use.

b. Repair leaky faucets! A 1/32 inch steady stream of water leaking from a hot water faucet could add up to 6,000 gallons wasted in one year, or the equivalent of 200 baths. Water leakage accounts for between 5-10 percent of all residential water consumption. To correct this problem, replace any worn washers. Consider replacing a conventional faucet with a single handle washerless valve faucet. This type faucet uses two smooth ceramic or hard plastic disks instead of a washer and seat, and produces a complete water seal. The washerless valve usually comes with a lifetime guarantee from the manufacturer which makes it maintenance-free and attractive.

A LITTLE DRIP MEANS A BIG ENERGY WASTE

THINGS YOU NEED:

-- An 8-ounce glass or plastic graduated measuring cup.
-- A pencil and some paper.
-- A leaky faucet (optional).
-- A clock.

Here's an experiment that shows you how serious the problem is with a leaky faucet. If you have a leaky faucet, use it. Otherwise, adjust your kitchen sink faucet (cold water) to produce a steady drip.

Simply place the measuring cup underneath the dripping faucet, and collect 15-minutes worth of drip. You might, for example, collect 4 ounces of water in 15 minutes.

c. Replace conventional washers with flow-reduction devices in kitchen sinks, shower heads, bathroom lavatories, and utility sinks. These are usually a metal fitting threaded at both ends for easy installation, a plastic "spool" inserted directly into the pipe, or any device that reduces the diameter of the water line. Without these devices, normal flow rates can be up to 12 gallons of water per minute. With them, the flow rate can be reduced to as little as 2 gallons of water per minute. A low-flow faucet may require more patience when filling a pail, but at 2 gallons per minute, it will only take 15 seconds to fill 2 quarts, which is not too inconvenient. Do not use flow reducers on faucets which supply dishwashers and clothes washers. These appliances operate on proper amounts of water filling the appliances in a timely manner. Restricting the flow will put an undue strain on the appliance, causing breakdown and added expense.

Now we have to do some arithmetic to find out how much energy was wasted. We'll use the 4-ounce figure in the example below:

Step 1: Multiply the number of ounces of water by 4--this gives you the number of ounces per hour leaking through the faucet.

4 ounces X 4=16 ounces per hour

Step 2: Multiply the answer from Step 1 by 24--this gives the number of ounces per day leaking through the faucet.

16 ounces per hour X 24=384 ounces per day

Step 3: Multiply the answer from Step 2 by 365--this gives the number of ounces per year leaking through the faucet.

384 ounces per day X 365=140,160 ounces per year

Step 4: Divide the answer from Step 3 by 128--this gives the number of gallons per year leaking through the faucet.

140,160 ounces per year ÷ 128= 1095 gallons per year

That's a lot of water! And it took a lot of energy to make it hot. You can figure out approximately how much oil, or gas, or electricity was wasted by doing the following calculations:

For an oil-fired water heater: Divide the answer from Step 4 by 110--this gives the approximate number of gallons of oil wasted.

1095 ÷ 110= 9.95 gallons of oil per year.

2. Personal Hygiene

Personal hygiene requires large amounts of hot water -- approximately 33% of daily water use. It takes about 30 gallons of water to fill the average bathtub. A shower with a flow rate of 4 gallons of water a minute uses only 20 gallons in 5 minutes. If the shower uses half hot and half cold water, this would be a savings of 5 gallons of hot water by showering instead of bathing. By substituting just one shower for one bath a day, there could be a savings of almost 2,000 gallons of hot water a year. If a flow reducing shower head were installed, cutting the flow rate to 2 gallons of water per minute, this savings could double. In a family of four, a flow reducing shower head which costs $20 and reduces the flow rate to 2 or 3 gallons of water per minute could pay for itself in 3 to 4 years.

Try bathing one after the other so that there will be full utilization of hot water stored in hot water pipes. Limit the shower to five minutes so that as little water as possible will run unnecessarily. Consider taking a shower by wetting the body, turning off the water while soaping, then turning the water back on to rinse. This can be done with some shower controls or with thermostatic mixing valves. These devices automatically mix hot and cold water to a desired temperature so that when it is turned off then back on again for rinsing the temperature will remain the same. This method of showering can save 10-40 percent of the warm water used in showers, but the costs of thermostatic mixing equipment is two to three times

For a gas-fired water heater: Multiply the answer from Step 4 by 0.84--this gives the approximate number of cubic feet of gas.

1095 X 0.84= 920 cubic feet of gas per year.

For an electric water heater: Multiply the answer from Step 4 by 0.25--this gives the approximate number of kilowatt-hours of electricity wasted.

1095 X 0.25= 274 kilowatt-hours per year

Heating water takes energy... lots of energy! A typical family uses over 25,000 btu of energy each year to heat water for washing everything from hands to dishes. It takes about 300 gallons of oil, or 36,000 cubic feet of natural gas, or 7,500 kilowatt-hours of electricity to do the job.

SHOULD YOU SHOWER OR TAKE A BATH?

THINGS YOU NEED:

-- Your bathtub.
-- A yardstick.
-- A bar of soap (optional).

Here's a surprising fact: If people who took baths took showers instead, we'd save a lot of energy. This experiment demonstrates what we mean.

Start by taking a bath. Fill your bathtub with water as usual, but before you step in, use your yardstick to measure the depth of water in the tub.

Next, take a shower. Before you begin, though, close the bathtub drain so that the shower water will collect in the tub. When you are finished, measure the depth of water that has collected. Compare this reading with the bath water depth.

the price of conventional equipment. This should be taken into consideration before purchase.

When shaving or rinsing items in a sink, fill the sink with water instead of permitting the faucet to run needlessly in an open sink. Do not permit the faucet to run until the water is the desired temperature before plugging the drain. Plug the drain at the beginning, thus capturing the 3 to 5 gallons of water that flow before hot water reaches a bathtub or sink.

3. Kitchen and Laundry

Twenty-five percent of household water is used in the kitchen and laundry. Most of the appliances requiring hot water are located in these two areas.

In the kitchen, use cold water rather than hot to operate a food disposer. Use cold water instead of hot water for rinsing vegetables and preparing food. Use a reduced flow rate device on slow settings for routine rinsing. Do not waste hot water rinsing dishes before putting them in the dishwasher; just scrape them off and put them in the dishwasher. When hand-washing dishes, first soak them in detergent to loosen baked on food and rinse them sparingly. Be sure to use the dishwasher for full loads only. Avoid the extra long, pre-wash, and soak cycles on the dishwasher unless absolutely necessary. This can save 3 to 7 gallons of hot water each time. Experiment with shorter cycles and less detergent to save on hot water.

You will find that your shower used substantially less water... probably less than half as much! A lot of this water is hot water.

As a rule of thumb, figure that it takes an ounce of oil (or a cubic foot of gas, or 1/4-kilowatt hour of electricity) to heat a gallon of water. So you can see that showering saves lots of energy.

Use cold water for washing clothes whenever possible. With many of the detergents on the market, as clean a wash as one in hot waterwill result. If hot water is used, consider having the hot water tank near the washer so that heat in the pipes will not escape needlessly.

There are two water-saving features built into many of the new automatic washing machines. One is the water level control. The variable water level control allows the level of the water flowing into the washing machine to be regulated to the appropriate washing need--a low-level setting for small wash loads, and medium, large, and extra-large settings or graduatingly larger loads.

Another feature is the suds-saver. This device allows the hot wash water plus detergent to be drained into a laundry tub for reuse in the next wash load. This saves heating a second load of wash water. This device features a 20-gallon reservoir which drains into a nearby utility sink; when the second load of wash is put into the washer, the tub is filled from this reserve. Though the cost of the device is only $15 to $20, the expense of installing a nearby utility sink may be more expensive than savings realized from reusable hot water.

Sort clothes before washing. This will help determine load sizes and will help group items which require certain water temperatures. Even if a load of clothes must be washed in hot water, it is not necessary to rinse them in hot water. Wash loads consecutively if possible to take advantage of the machine being warm. Other suggestions for saving hot water or using it more efficiently when washing dishes or laundry are given in Module V.

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

UNIT II

WATER CONSERVATION

UNIT OBJECTIVES

1. Appreciate and explain the amount of cold water used in the home for various activities.
2. Discuss water saving opportunities in the home.
3. Explain the direct and indirect energy use for producing and supplying water for consumer use.

MODULE VI

HOT WATER HEATING CONSERVATION OPPORTUNITIES

UNIT II

WATER CONSERVATION

LECTURE

ACTIVITIES

Conservation in all forms is the attitude people are taking today. The consumer is aware of the fuel shortage and unnecessary waste of fossil fuels the facing the nations today. Most people do not consider water as a resource which is in short supply. In most areas of the country, it is not an endangered resource, and it is a renewable resource. However, in some parts of the South where hot, dry climates prevail, water can be a precious commodity. Regardless of the shortage of water to the home, treatment plants required to purify the water before it is used and treat it after it is used, and pumping stations to transport it to and from the home require energy. Most municipal water supply treatment plants are inadequately designed and overburdened. In most cities and towns, rain, household waste water, and industrial wastes enter the same collection system. Clean rain water becomes contaminated by polluted water. Overload from heavy precipitation floods sewage treatment facilities and allows polluted water to pass directly into rivers and streams.

In 1972, Congress took decisive action to renew water resources by amending the Federal Water Pollution Control Act, setting 1983 as the goal date for making the nation's rivers and lakes clean enough for recreational purposes and to help protect sources of drinking water from pollution. The Environmental Protection Agency (EPA) is managing billions of dollars, in partnership with state and local agencies, to attain this goal. Any measure the consumer can initiate to conserve water at home--even cold water--means saving energy indirectly.

A. BATHROOM

The major user of cold water in the home is the toilet, which accounts for about 40 percent of a city's water use. Tank-type toilets normally consume between 5 and 8 gallons of fresh water per flush to sweep away less than a pint of waste. This can be reduced by 3 to 3 1/2 gallons by installing new water-saving toilet tanks. These are designed to give full flushing action but reduce the water requirement to about 3 gallons per flush. It may not be economically feasible to replace present fixtures with these new ones since they are fairly expensive. There are some measures which can be taken with a conventional tank, however. Consider putting bricks or water filled bottles in the tank to displace a certain amount of water. This will allow the tank to fill to its normal level--minus the space displaced by the bricks. Another method is to adjust te float so that the tank does not fill to its original level. This does not work well since the tank must build certain pressure from the height of the water line in order to flush properly. One drawback of these devices is that it may take two flushes to adequately rid the toilet of waste; this would cancel any water saving benefits. Several commercial products are available as tank inserts and special flush valves which are inexpensive.

Another consideration for toilets is the number of waterless units available on the market. These include compost toilets which compost toilet wastes as well as kitchen scraps. Other units include chemical recirculating toilets, incineration toilets, and greq water sytems for large housing projects. Grey water is defined as recirculated, non-potable water.

B. OUTDOORS

Be conservative with outdoor water use. This does not mean stop watering the lawn, but become conscious of ways to better utilize water for this purpose. The impact on energy savings on outdoor watering is not as great as on indoor use because the water does not enter the sewage system. However, many homes use a great deal of water outdoors -- over 200,000 gallons on lawns with automatic sprinklers, for instance. Plant groundcovers such as ivy or iceplant instead of lawn grass because they take less water. Water in the mornings or late evenings when temperatures are not too high in order to cut down on evaporation. Time watering periods. Locate sprinklers so that they do not spray sidewalks, the house, or run down driveways into the curb. When washing a car, use a self-closing nozzle or the hose so that the water can be closed off while soaping the car.

C. SUMMARY

Other water saving tips for both indoor and outdoor use of water include the following.

Do not use garbage disposals. They waste water and energy to operate. They chop solid garbage, mix it with water, and send it to a treatment plant where money and energy are spent to remove the garbage from the water.

Repair dripping faucets; leaks can lose up to 400 gallons of water a day.

Do not leave water running needlessly; turn off water while brushing teeth or shaving.

Install an aerator on the kitchen faucet. This reduces the volume of water flowing, but it is hardly noticeable.

Save laundry rinse water to put on the garden or lawn, in compost, or to wash the car.

In warm weather, wash the car during a rain--if there is no lightning.

Let the rain water the garden. In a dry spell, give plants one soaking per week in the early morning or late evening.

Collect rain in a barrel or cistern for use around the house.

Reduce flushing toilets whenever possible.

Pre-soak or use a soak cycle when washing heavily soiled clothes. This will avoid a possible second washing.

Install water flow reducers in showers and faucets.

Limit the time in a shower; a 5-minute shower can use up to 60 gallons of water.

Time each shower; unless it can be completed in 4 minutes, a bath might use less water.

For baths, fill the tub only one-fourth full.

Remember, the philosophy of using any resource is using it efficiently. This does not mean doing without; it means getting the most from energy or the resource spent.

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

UNIT III

CONSIDER SOLAR WATER SYSTEMS

1. Describe the components and operation of a typical solar water heating system.
2. Compute cost for installing and savings realized for using solar energy to heat domestic hot water.
3. Distinguish the characteristics of the two basic kinds of solar water heating systems.
4. Review the facts and considerations necessary before deciding on solar water heating for a specific situation.

MODULE VI

HOT WATER HEATING CONSERVATION OPPORTUNITIES

UNIT III

CONSIDER SOLAR WATER HEATING

LECTURE

Solar water heaters are the most popular way to use solar energy and the most economical at present to install. Tax incentives were written into law in late 1978, giving the homeowner a maximum income tax credit of $2,200 for installing solar or other renewable energy sources in the home.

Solar water heaters are competitive today in areas where electric water heaters must be used. Up to 17 percent of a home's energy consumption is for heating water. It it is heated by electricity at a price of 4¢ per kilowatt-hour, the monthly water heating bill is about $20 to heat 100 gallons of water per day. If a solar system will serve the family with 80 percent of its hot water needs, and the conventional electric hot water heater serves the remaining 20 percent, the monthly bill could be reduced $16 per month. Calculating a 30-year mortgage on a $1,400 solar system, the resulting savings will be $4 per month.

Therefore, a solar water heating system might be considered. If, however, water is heated with natural gas at a price of 17¢ per day, (the average cost for 100 cubic feet of gas which typically heats 100 gallons of water per day) the bill will be about $5.17/month. This is much cheaper than solar.

ACTIVITIES

Solar system installed	$1,400
80% solar @ 30 yr. mortgage=	$12/month
20% electric water heater =	$ 4/month
Total bill for heating water	$16/month

Deregulation of natural gas and escalating prices could change this situation and make solar energy more competitive with natural gas.

A solar water heating system can cost less than $1,000 if some of the work is done by the homeowner. Most systems, however, cost between $1,800 and $2,100--installed. With the annual increase in electricity rates estimated at 4 percent, a solar water heating system that lasts 20 years and costs $1,000 could repay itself in 10 years or less, giving "free" hot water for the remainder of the system's life.

A solar water system does not replace a conventional hot water system--it only supplements it. A solar system is capable of providing water at 115° to 165°, depending on the cloud conditions and outside temperature. Therefore, the solar water system might serve as a preheat for conventional water heating systems requiring gas or electricity, to bring up the water temperature to the desired temperature.

A. SOLAR ENERGY SYSTEMS

All solar heating systems operate in much the same way. The basic parts of the system are: the collector, storage, distribution, controls, and auxiliary energy source. The flat-plate collector is the most widely used type for low-temperature water heating. Most collectors use liquid as the heat transfer medium; however, some systems use air for water heating.

Figure 3.1 shows a collector with its following components: glazing (A), usually double-strength glass installed with gaskets or caulking to allow expansion and contraction due to temperature changes; water tubes (B) that are attached above, below, or integral to the absorber plate for heat transfer; the absorber plate (C) which usually is metal and is treated with a black paint or dark "selective" coating to improve the plate's ability to absorb heat. The selective finishes are special coatings which absorb most of the sun's rays, thus increasing the efficiency of the collector. The insulation must be able to withstand high temperatures that occur when the collector is operating. The enclosure (E) is a container for the components listed above. Together with the glazing, the enclosure makes the collector weathertight.

EXPLODED CROSS-SECTION THROUGH A
TYPICAL FLAT PLATE SOLAR COLLECTOR

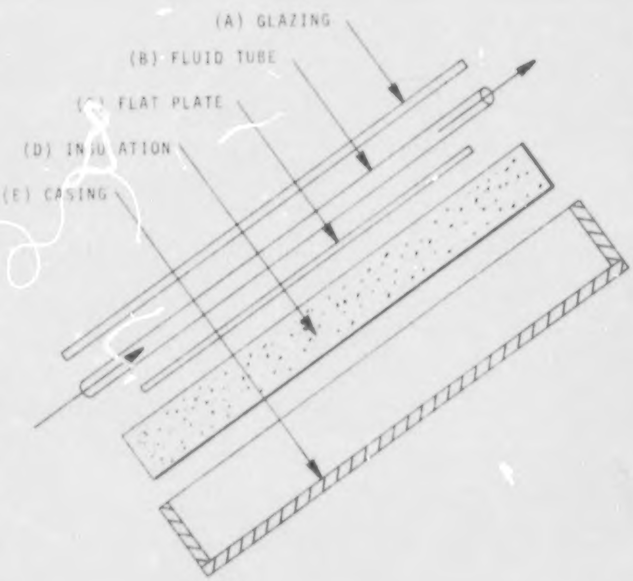


FIGURE 3.1

B. KINDS OF SYSTEMS

There are two basic kinds of systems today for most solar water heating: the open system and the closed system.

An open system essentially heats water through the collector and circulates it through a storage tank. This water is used for domestic water consumption, just as water from a conventional water heater is used.

Open systems can be either thermosyphon or forced water. The thermosyphon system is the simplest solar water heating system. It combines a flat-plate collector with a storage tank mounted above the collector. The tank is placed high enough for cold water in the downcomer tube to displace by convection the hot water in the collector, thus causing a slow circulation of water. (Figure 3.2)

In a good sunny location, free from shade, a 4 x 8-foot collector can heat 40-50 gallons of water a day. The piping and storage tank should be well insulated to avoid heat loss.

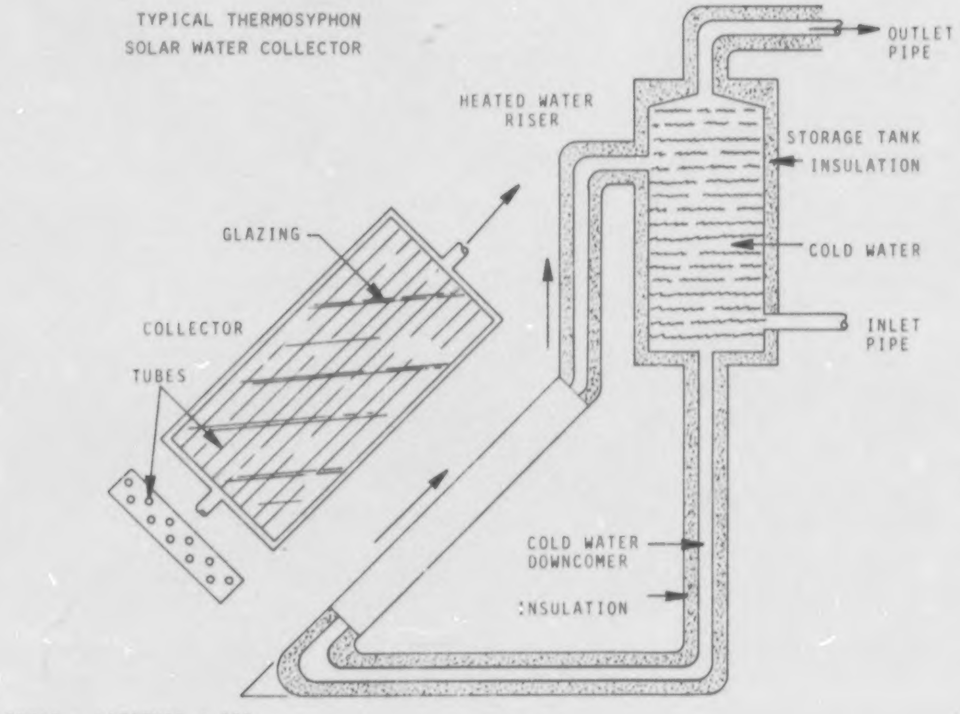

TYPICAL THERMOSYPHON
SOLAR WATER COLLECTOR
OUTLET PIPE
HEATED WATER RISER
STORAGE TANK
INSULATION
GLAZING
COLD WATER
COLLECTOR
INLET PIPE
TUBES
COLD WATER DOWNCOMER
INSULATION
ANGLE = LATITUDE + 10%

FIGURE 3.2

A forced water system contains the same components as the thermosyphon system with the addition of a pump to force the hot water from the collector to the storage tank. The advantage of this system is that the tank can be located any convenient place, not just above the collector. Controls must also be added to ensure that the water returning to the tank is warmer than the water leaving it. (Figure 3.3)

ROOF MOUNTED PUMPED SOLAR
WATER HEATING SYSTEM

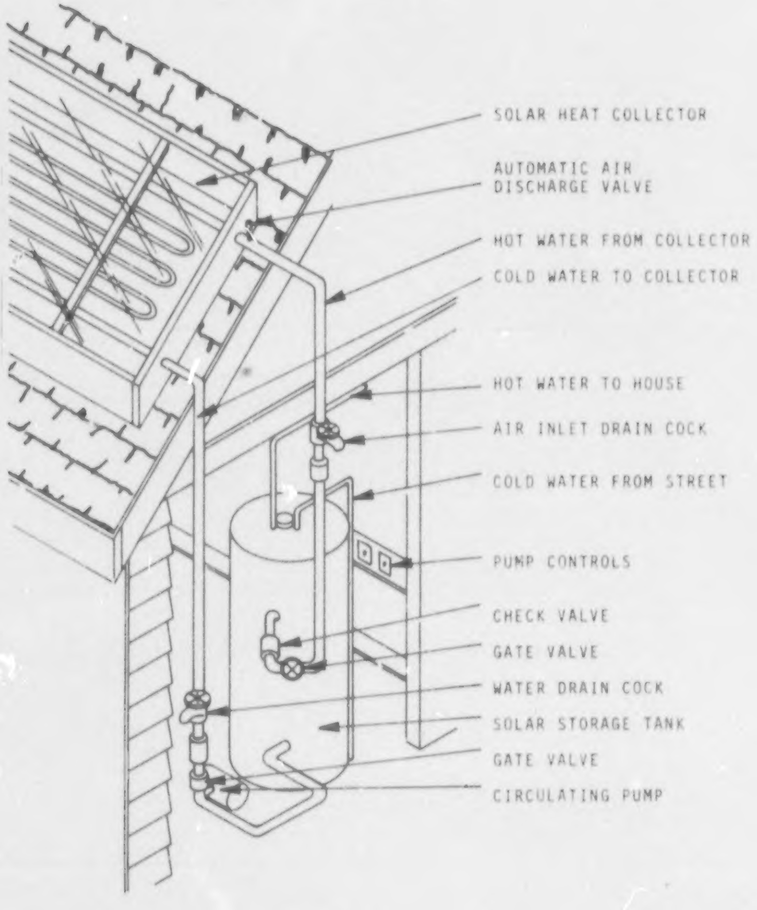

SOLAR HEAT COLLECTOR
AUTOMATIC AIR DISCHARGE VALVE
HOT WATER FROM COLLECTOR
COLD WATER TO COLLECTOR
HOT WATER TO HOUSE
AIR INLET DRAIN COCK
COLD WATER FROM STREET
PUMP CONTROLS
CHECK VALVE
GATE VALVE
WATER DRAIN COCK
SOLAR STORAGE TANK
GATE VALVE
CIRCULATING PUMP

FIGURE 3.3

Both kinds of open systems require a drain-down feature that allows all water to drain out of the collectors in order to prevent freeze damage. In some Texas locations that have mild winters, such as Houston, the danger of freezing may be alleviated in a forced water system by continuing to pump the warm stored water through the collector. Of course, this results in additional heat loss through the collector and requires the use of the back-up heating system.

A closed system includes a heat exchanger and a treated water solution (antifreeze mixed with water) in a closed loop. (Figure 3.4) The treated solution circulates through the collector where it is heated. This solution in turn transfers heat to the home water supply through the heat exchanger. Heat exchangers should be external to the storage tank in order to ensure a double wall between the potentially toxic treated solution and the potable water supply. A closed system can also be thermosyphon or forced water.

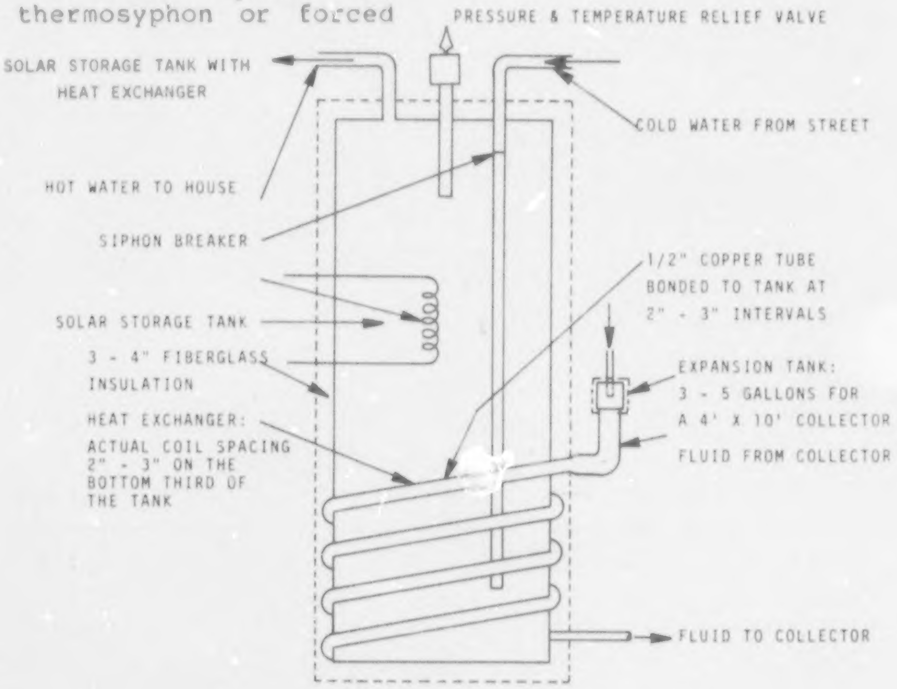

PRESSURE & TEMPERATURE RELIEF VALVE
SOLAR STORAGE TANK WITH HEAT EXCHANGER
COLD WATER FROM STREET
HOT WATER TO HOUSE
SIPHON BREAKER
1/2" COPPER TUBE BONDED TO TANK AT 2" - 3" INTERVALS
SOLAR STORAGE TANK
3 - 4" FIBERGLASS INSULATION
EXPANSION TANK: 3 - 5 GALLONS FOR A 4' X 10' COLLECTOR
HEAT EXCHANGER: ACTUAL COIL SPACING 2" - 3" ON THE BOTTOM THIRD OF THE TANK
FLUID FROM COLLECTOR
FLUID TO COLLECTOR

FIGURE 3.4

C. THE FINAL DECISION

After reviewing the kinds of solar water heating equipment available, the anticipated life-cycle cost of the systems compared to present fuel costs, and the intended use for the system, consult with a designer, installer, or engineer who has solar experience. Also, keep in mind that the most economical installation is with new structures.

More attention is being given to solar. It is important to weigh all facts before investing in it.

The National Solar Heating and Cooling Information Center makes the following suggestions for consideration when buying solar equipment:

1. Ask for proof that the product will perform as advertised. An independent laboratory or university report should be consulted.

2. Examine the warranty carefully. According to law, the manufacturer must state whether the warranty is full or limited. Ask the seller what financial arrangements, such as an escrow account, have been made to honor the warranties.

3. Solar components should work well together. If the system you are buying is not sold as a single package by one manufacturer, be sure that the seller has experience in choosing compatible components.

4. Be sure you will know specifically who will service the solar system if anything goes wrong--not just any plumber or tinkerer can do the job.

5. Don't try a do-it-yourself kit unless you really have a solar background as a repair person.

6. Check with your local consumer office or Better Business Bureau to determine whether the seller is reputable.

7. If the seller makes verbal claims that are not reflected in the literature handed out, have the claims written down and have the seller sign the statement.

8. If you have what appears to be a legitimate complaint, notify the local district attorney's office.

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

POSTTEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. About _______ gallons of heated water a day is used by the average American family (of 4) for indoor use:

   a. 15
   b. 25
   c. 55
   d. 75

2. About _______ percent of the annual home energy bill is used for the heating of water:

   a. 15
   b. 25
   c. 45
   d. 55

3. The average American family of four uses approximately 300 gallons of water a day for indoor use.

   a. true b. false

4. The second largest household use of gas, electricity, and oil is the heating of water.

   a. true b. false

5. Water heater flues should not be capped because it interferes with the circulation of air.

   a. true b. false

6. A gas water heater heats water faster than an electric water heater.

   a. true b. false

7. An electric water heater does not require a flue pipe.

   a. true b. false

8. A gas water heater is more expensive to operate than an electric water heater.

   a. true b. false

9. An electric water heater does not have any advantages over a gas water heater.

   a. true b. false

10. A single-handle washerless valve faucet will not save you any water.

    a. true b. false

11. It is advantageous to place the water heater near the major hot water users in the home.

    a. true b. false

12. It is not necessary to wrap hot water service pipes. Such wrapping does little to conserve energy.

    a. true b. false

13. In heating water, about ______ percent of the energy consumed for heating the water is lost through the tank wall:

    a. 10
    b. 15
    c. 25
    d. 50

14. Most electric water heaters use 120 volts.

    a. true b. false

15. It is true that bathing in a shower generally requires less water than bathing in a tub.

    a. true b. false

16. About 25 percent of household water is used in the kitchen and laundry.

    a. true b. false

17. The toilet is the major user of cold water in the home.

    a. true b. false

18. If you water outdoor plants early in the morning or late at night rather than during the middle of the day, you will save water.

    a. true b. false

19. It is true that an aerator installed on the kitchen faucet increases the volume of water flowing.

    a. true b. false

20. One really interested in saving energy should not use garbage disposals.

    a. true b. false

MODULE VI

WATER HEATING CONSERVATION OPPORTUNITIES

ANSWERS TO POSTTEST

1. d. 75
2. b. 25
3. a. true
4. a. true
5. b. false
6. a. true
7. a. true
8. b. false
9. b. false
10. b. false
11. a. true
12. b. false
13. c. 25
14. b. false
15. a. true
16. a. true
17. a. true
18. a. true
19. b. false
20. a. true

AVERAGE ANNUAL KWH BY APPLIANCE

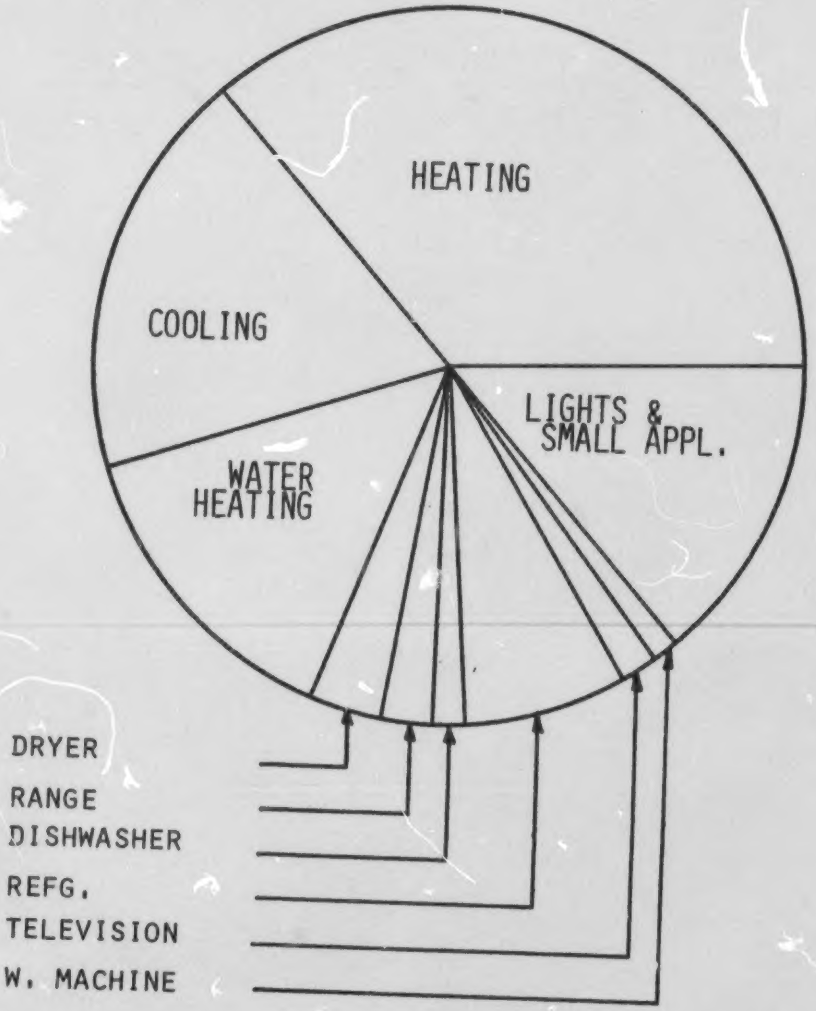
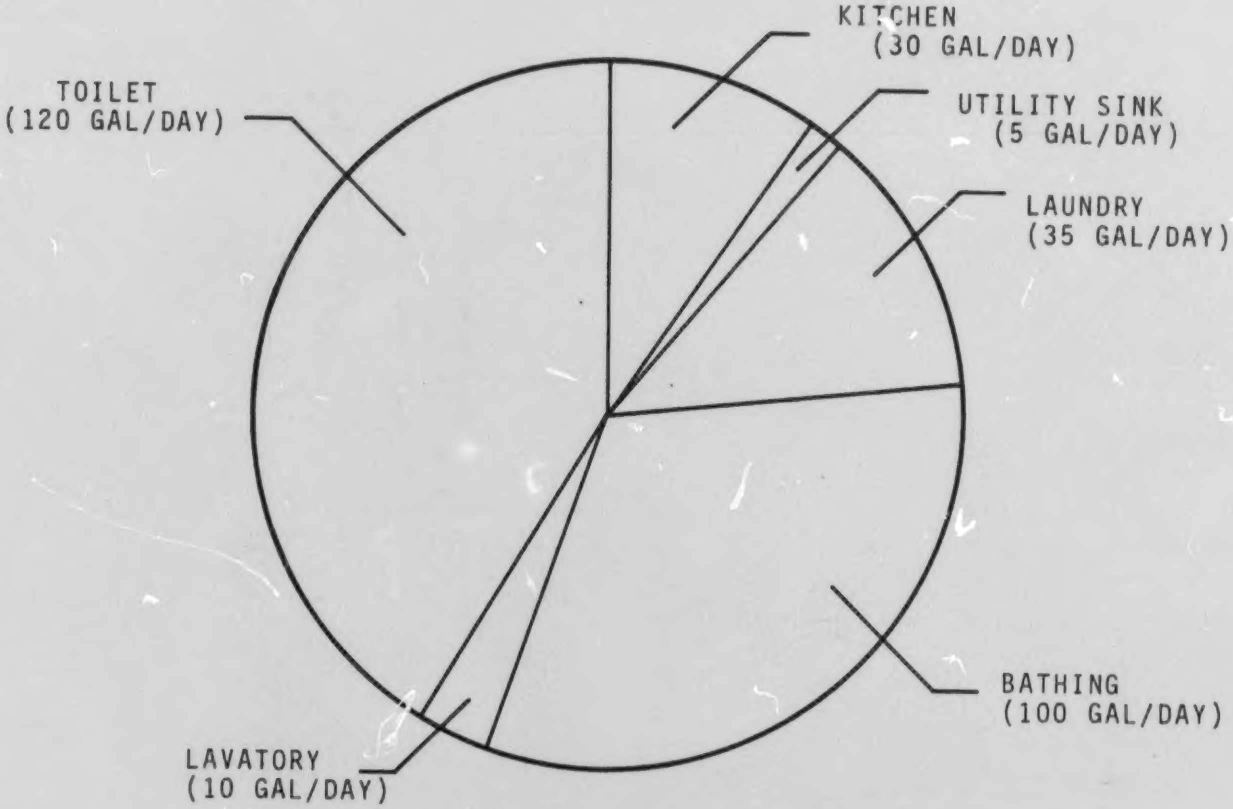


FIGURE 1.1

WATER CONSUMPTION IN A TYPICAL HOME (FAMILY OF FOUR)



SOURCE: EUGENE ECCLI, LOW-COST, ENERGY-EFFICIENT SHELTER FOR THE OWNER AND BUILDER, 1976.

FIGURE 1.2

THE GAS WATER HEATER

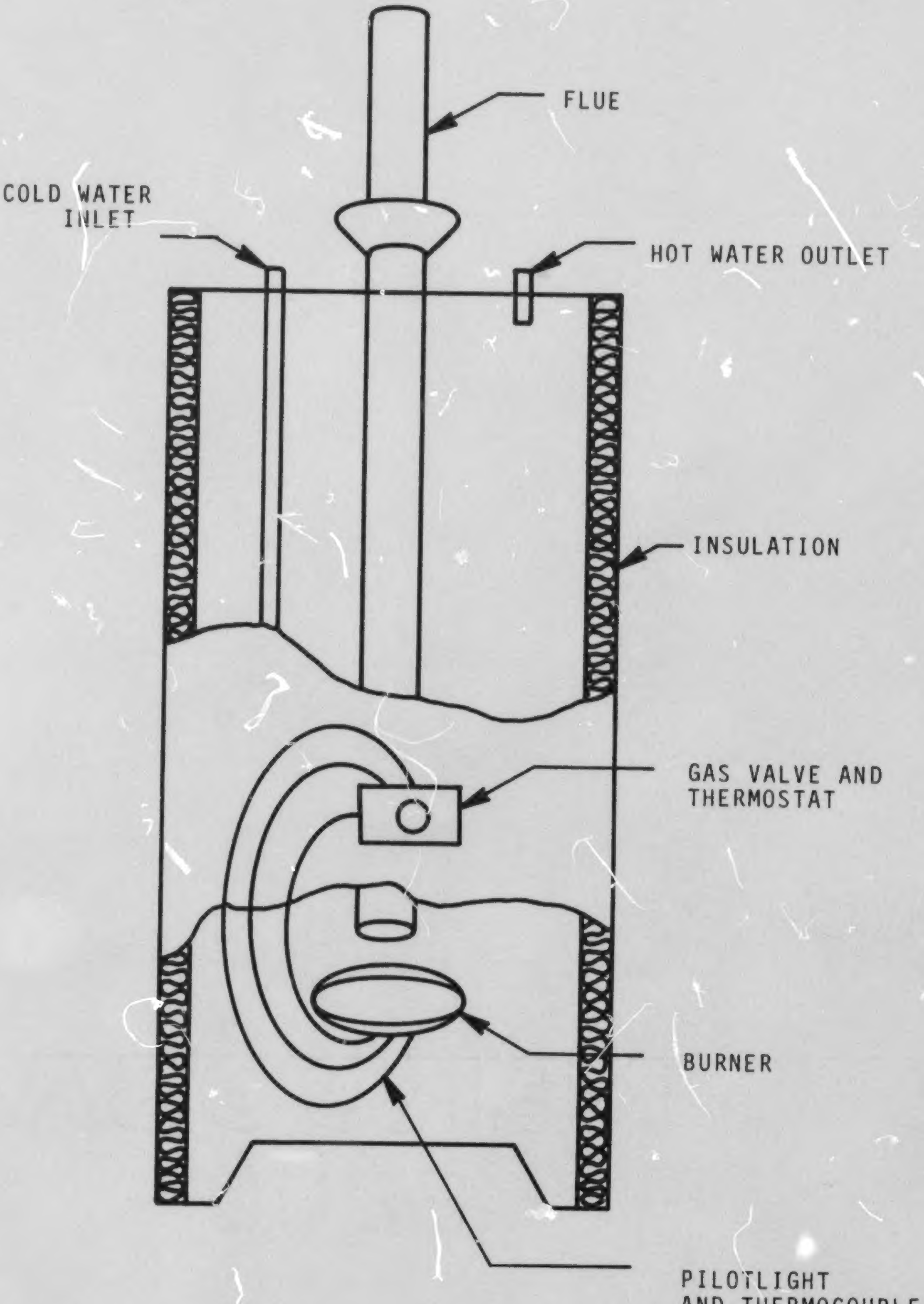

FLUE
COLD WATER INLET
HOT WATER OUTLET
INSULATION
GAS VALVE AND THERMOSTAT
BURNER
PILOTLIGHT AND THERMOCOUPLE

FIGURE 1.3

THE BELTED-ELEMENT ELECTRIC WATER HEATER

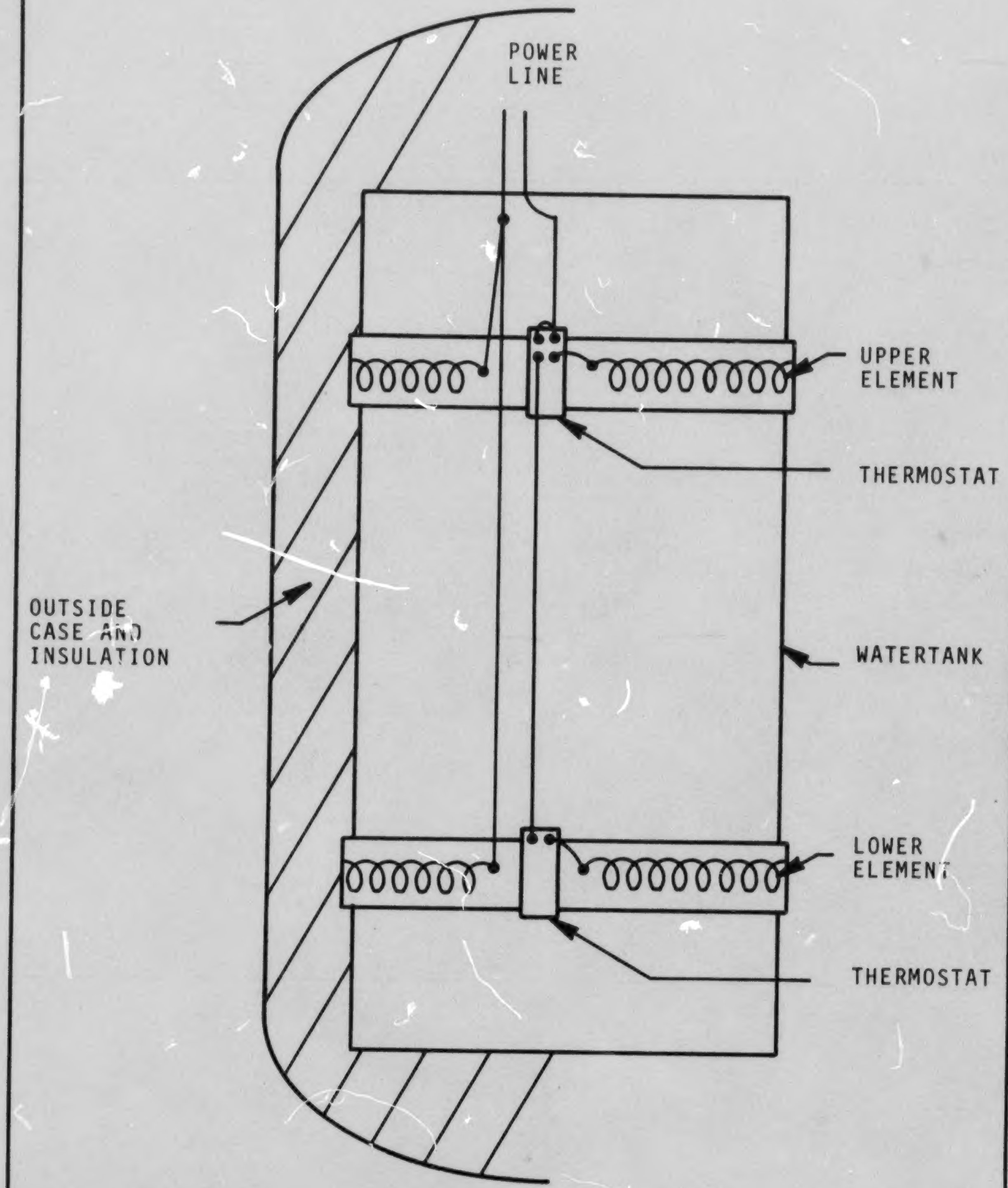

POWER LINE
UPPER ELEMENT
THERMOSTAT
OUTSIDE CASE AND INSULATION
WATERTANK
LOWER ELEMENT
THERMOSTAT

FIGURE 1.4

THE SUBMERSIBLE-ELEMENT WATER HEATER

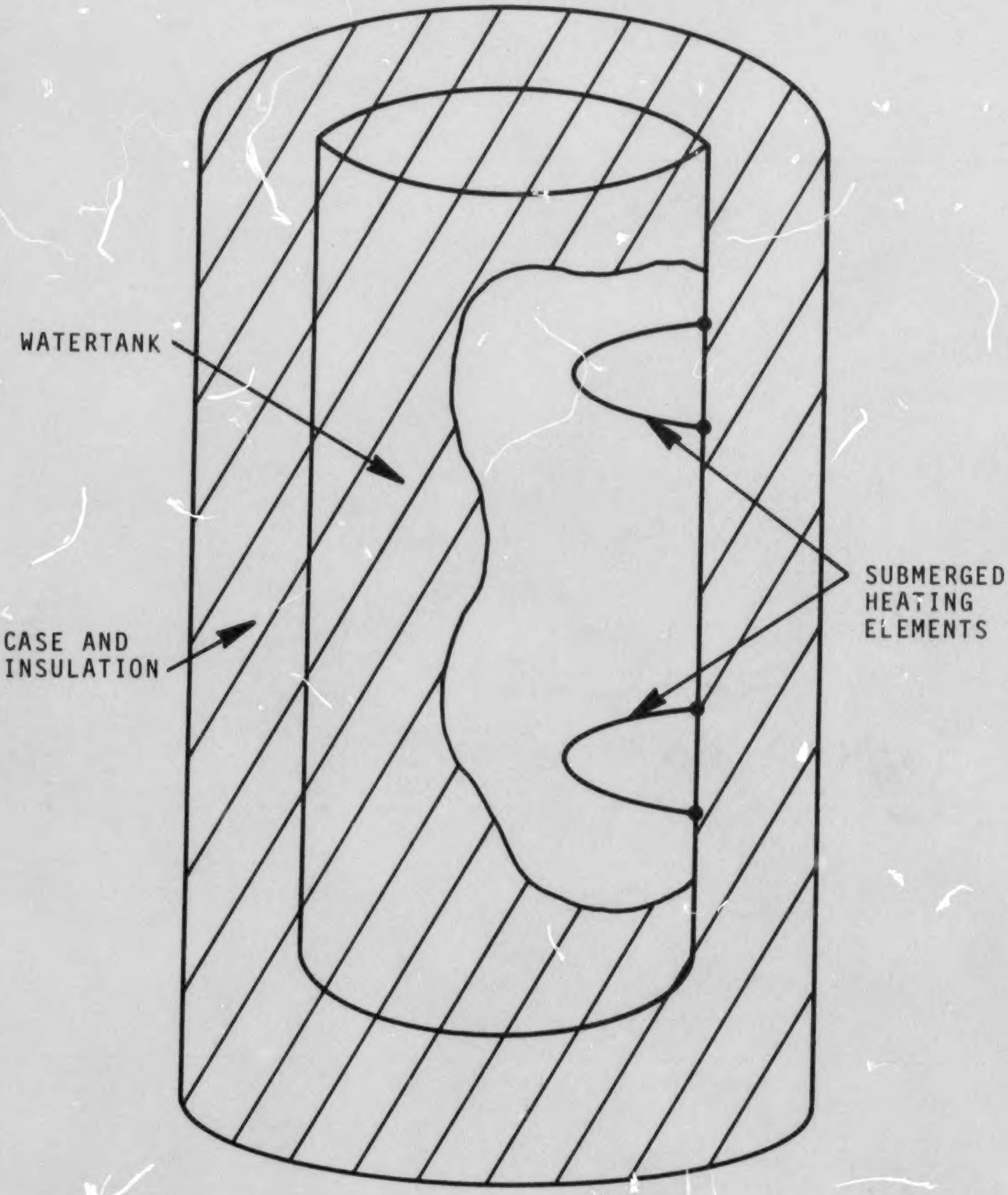

WATERTANK
CASE AND INSULATION
SUBMERGED HEATING ELEMENTS

FIGURE 1.5

EXPLODED CROSS-SECTION THROUGH A
TYPICAL FLAT PLATE SOLAR COLLECTOR

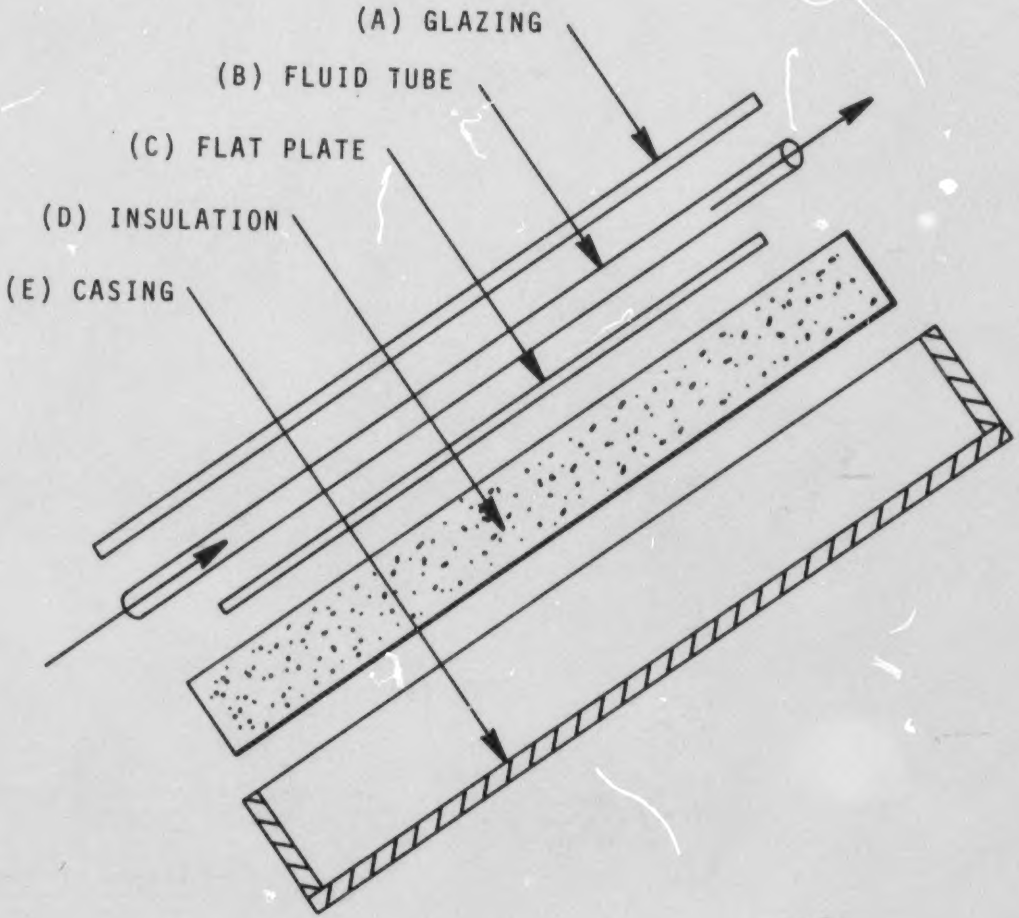
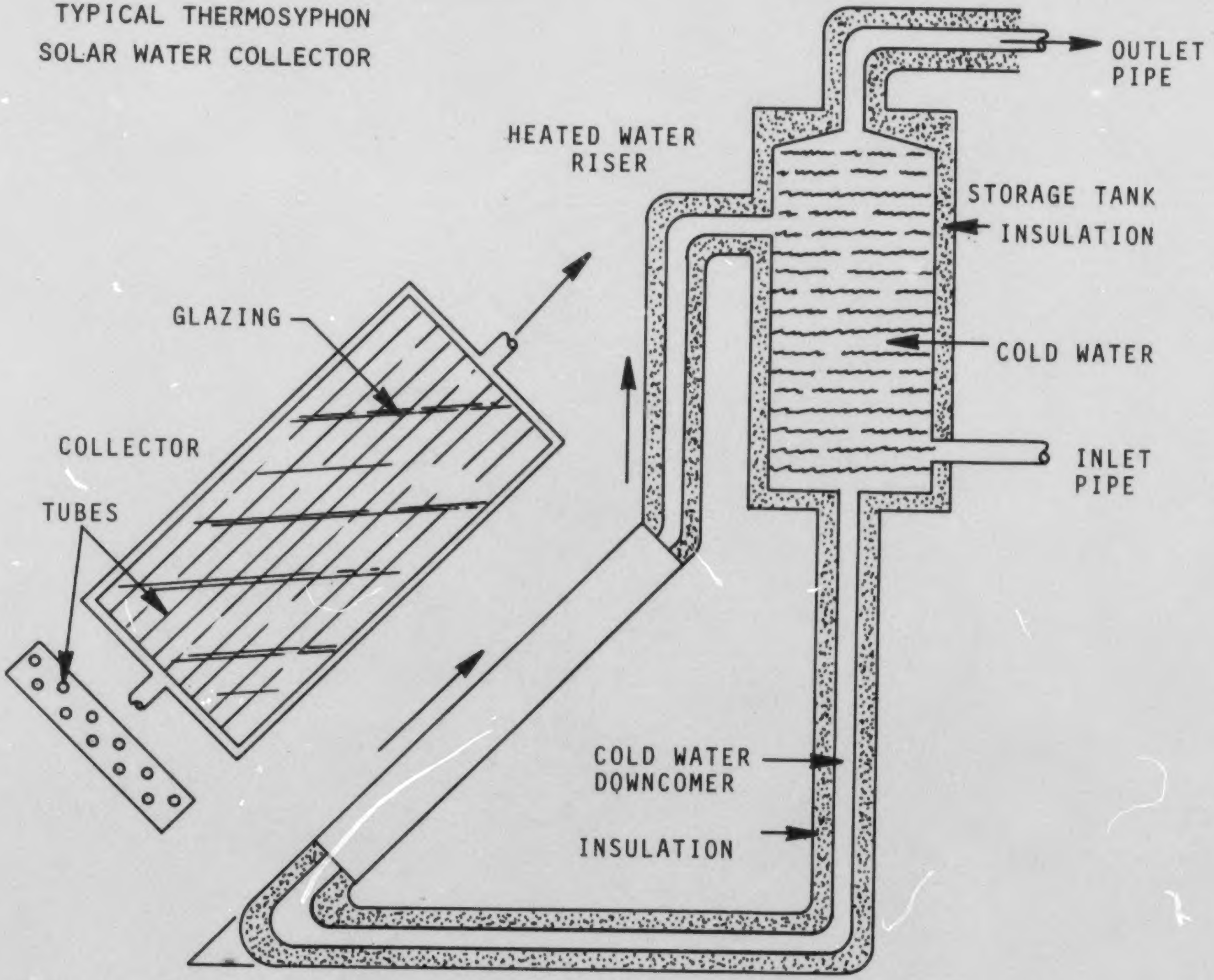

(A) GLAZING
(B) FLUID TUBE
(C) FLAT PLATE
(D) INSULATION
(E) CASING

FIGURE 3.1

TYPICAL THERMOSYPHON
SOLAR WATER COLLECTOR


OUTLET PIPE
HEATED WATER RISER
STORAGE TANK
INSULATION
GLAZING
COLD WATER
COLLECTOR
INLET PIPE
TUBES
COLD WATER DOWNCOMER
INSULATION

ANGLE = LATITUDE + 10%

FIGURE 3.2

ROOF MOUNTED PUMPED SOLAR WATER HEATING SYSTEM

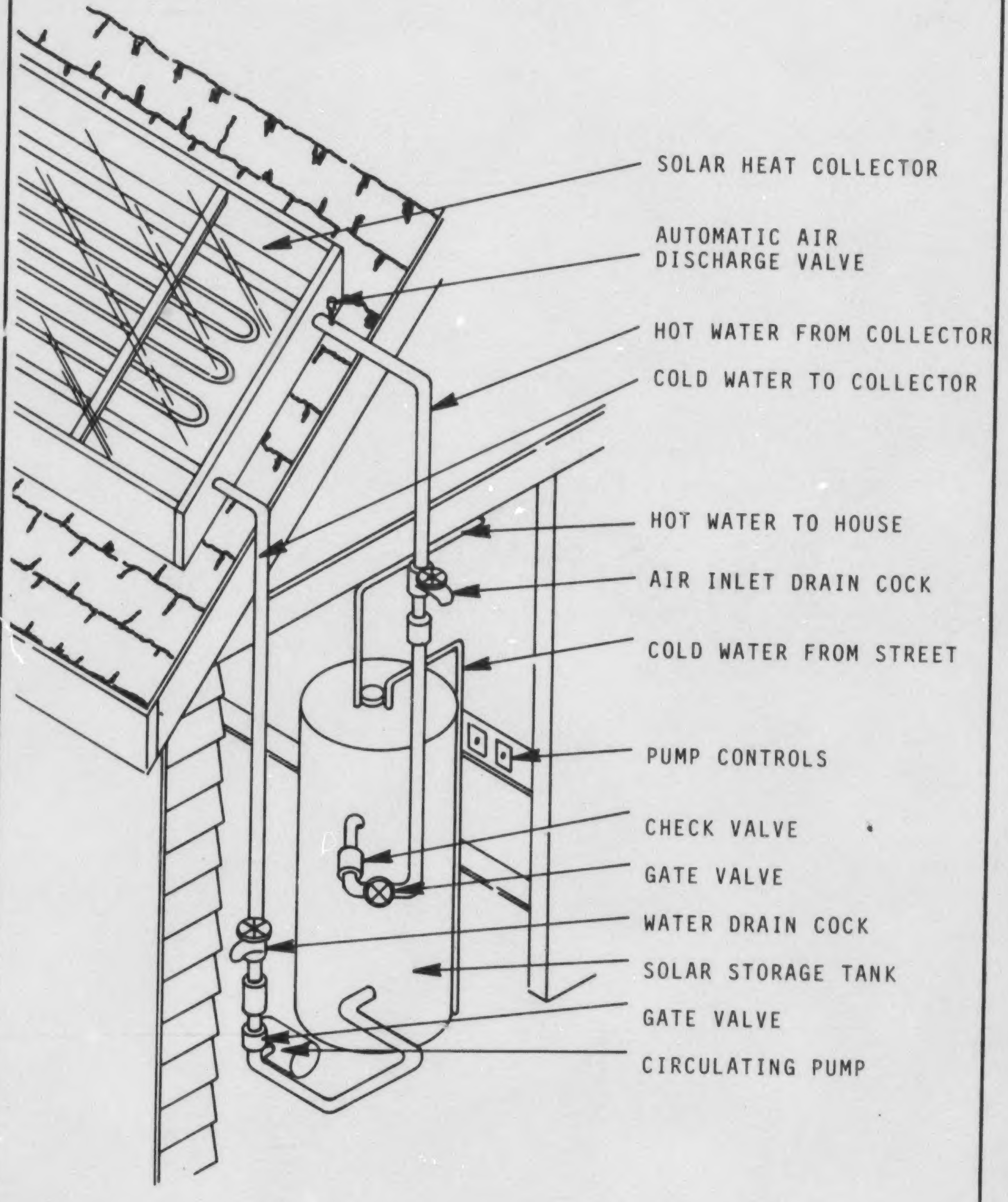
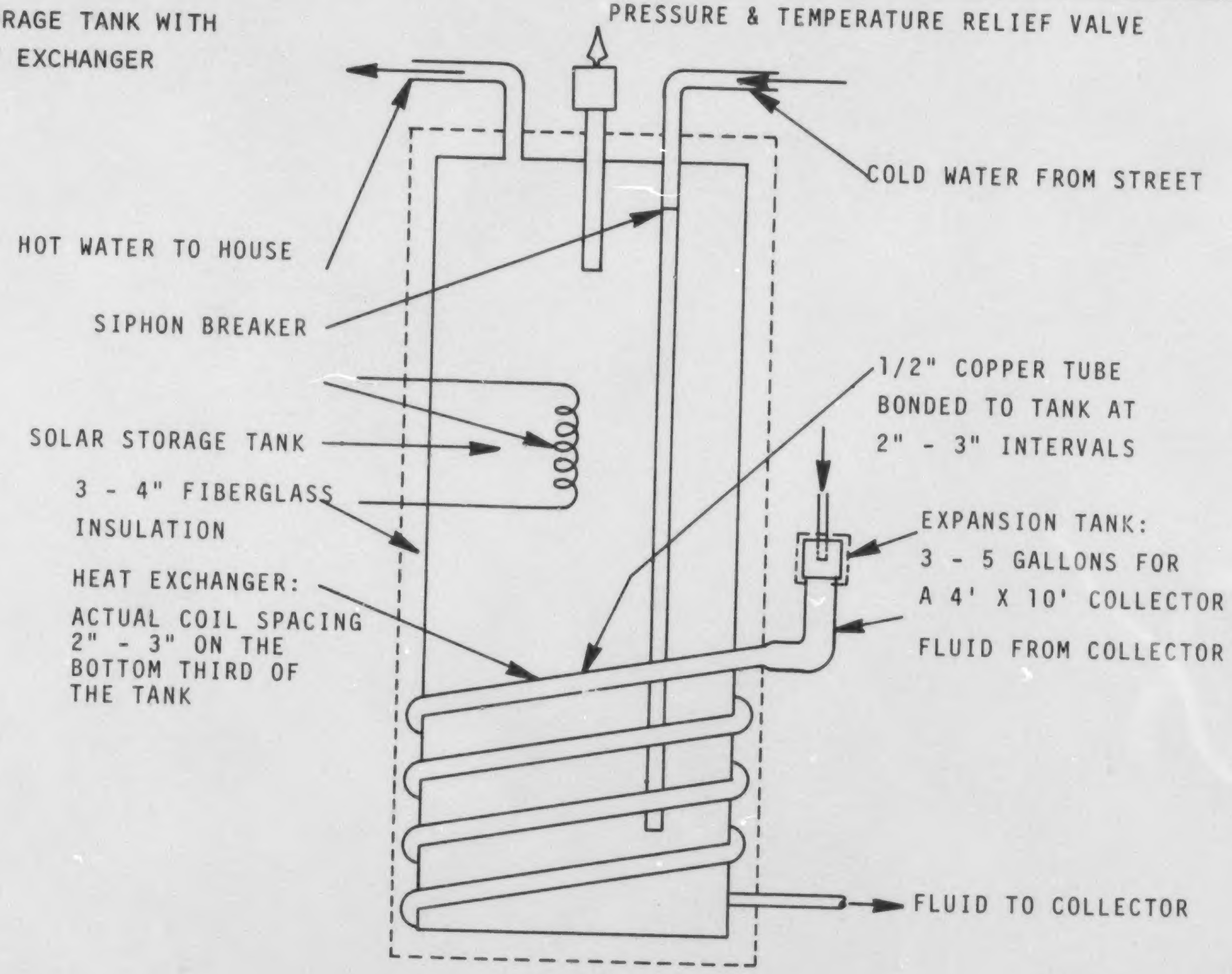

SOLAR HEAT COLLECTOR
AUTOMATIC AIR DISCHARGE VALVE
HOT WATER FROM COLLECTOR
COLD WATER TO COLLECTOR
HOT WATER TO HOUSE
AIR INLET DRAIN COCK
COLD WATER FROM STREET
PUMP CONTROLS
CHECK VALVE
GATE VALVE
WATER DRAIN COCK
SOLAR STORAGE TANK
GATE VALVE
CIRCULATING PUMP

FIGURE 3.3

SOLAR STORAGE TANK WITH HEAT EXCHANGER


PRESSURE & TEMPERATURE RELIEF VALVE
COLD WATER FROM STREET
HOT WATER TO HOUSE
SIPHON BREAKER
1/2" COPPER TUBE BONDED TO TANK AT 2" - 3" INTERVALS
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3 - 4" FIBERGLASS INSULATION
EXPANSION TANK: 3 - 5 GALLONS FOR A 4' X 10' COLLECTOR
HEAT EXCHANGER: ACTUAL COIL SPACING 2" - 3" ON THE BOTTOM THIRD OF THE TANK
FLUID FROM COLLECTOR
FLUID TO COLLECTOR

FIGURE 3.4

MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. Appliance Energy Conservation Opportunities may be offered by itself or as a part of a sequence of three modules in the following order:

Order	Module	Title of Module
1	3	Understanding Utility Bills
2	5	Lighting Conservation Opportunities
3	7	Appliance Energy Conservation Opportunities

MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

MODULE DESCRIPTION:

The student will be introduced to various household and small commercial appliances. These appliances will be discussed in terms of their operation, energy usage, efficiency ratings, and cost of operation. Alternatives to use of these appliances, and methods for making their use more efficient will be presented. A survey of energy usage by these appliances will be provided with a discussion of the benefits of applying available energy conservation opportunities. The student will learn to determine the energy efficiency ratings of appliances and apply the ratings to energy conservation opportunities.

GOAL STATEMENT:

The objective of this module is to train secondary and post-secondary students in the recognition, implementation, and utilization of energy consumption, and possible opportunities for conservation in the use of residential and small commercial appliances.

READING GRADE LEVELS:

Lecture: 13
Lab : 8

SUGGESTED TEACHING TIMES:

Secondary : 1 hour
Postsecondary: 1 hour

UNITS:

- I. Appliance Energy Use
  - A. Refrigerator/Freezer
  - B. Cooking
  - C. Dishwasher
  - D. Washing Machine
  - E. Clothes Dryer
  - F. Minor Appliances
  - G. Appliance Energy Conservation Tips
- II. The Appliance Labeling Program

MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

TERMINOLOGY

Ampere--The unit of electric current as the force of attraction between two parallel current-carrying conductors.

Appliance--an instrument or device designed for a particular use; a household or office device (e.g., a stove, fan, or refrigerator) operated by gas or electric current.

Kilowatt-hour--a unit of energy or work equal to 1000 watt-hours; equal to about 3,400 Btu .

Thermostat--an automatic control device actuated by temperature, and designed to be responsive to temperature.

Volt--the unit of measure of electric force. The voltage in the circuit is what makes the current flow.

Watt--the unit of electrical power--found by multiplying the voltage times the ampere.

MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

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MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. Americans represent approximately 6 percent of the total world population and consume _______ percent of the total energy consumed in the world:

   a. 10
   b. 13
   c. 23
   d. 33

2. Approximately _______ percent of the homeowner's energy usage is to operate electrical home appliances:

   a. 1
   b. 4
   c. 6
   d. 8

3. An appliance with a wattage rating of 1,000 uses _______ KWH of electricity for every hour it is operation:

   a. 1
   b. 2
   c. 3
   d. 4

4. By multiplying the customer's cost of one_______ of electricity by the KWH of energy used per hour, the cost of one hour's operation can be determined for any appliance:

   a. volt
   b. ohm
   c. kilowatt
   d. watt

5. The two major uses of appliances in the home...after heating and cooling and hot water heating...are for _______ and _______:

   a. refrigeration and cooking
   b. disposals and dryers
   c. radio and television
   d. can openers and knife sharpeners

6. The average wattage of the oven of a range is less than that of a microwave oven.

   a. true   b. false

7. An automatically defrosting refrigerator's wattage is less than that of the refrigerator that requires manual defrosting.

   a. true b. false

8. When excessive frost accumulates on the evaporator unit of a refrigerator, the appliance must run for longer periods of time to cool food.

   a. true b. false

9. The refrigerator should be set on:

   a. 33°F - 34°F
   b. 38°F - 40°F
   c. 45°F - 50°F
   d. 50°F - 55°F

10. A freezer or refrigerator requires a great deal of electric current when it first starts up.

   a. true b. false

11. Water will come to a boil faster and require less energy in a covered pan than in an open pan.

   a. true b. false

12. A pressure cooker can save you money for energy.

   a. true b. false

13. The dishwasher does not have to heat the water that comes to it from the water heater.

   a. true b. false

14. It costs you more if you let your dishwasher dry your dishes.

   a. true b. false

15. Using too much detergent in your washer will require the machine to use more energy.

   a. true b. false

16. Unremoved lint on the lint screen of your dryer will not cause the machine to use more energy.

   a. true b. false

17. Appliances kept in good working order will use less energy than poorly maintained appliances.

   a. true b. false

18. An electric clock requires a great deal of energy.

    a. true b. false

19. A solid state television requires more energy than a tube type television.

    a. true b. false

20. The FTC's appliance labels provide information about energy costs in various ways.

    a. true b. false

MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

ANSWERS TO PRETEST

1. d. 33
2. d. 8
3. a. 1
4. c. kilowatt
5. a. refrigeration and cooking
6. b. false
7. b. false
8. a. true
9. b. 38°F - 40°F
10 a. true
11. a. true
12. a. true
13. b. false
14. a. true
15. a. true
16. b. false
17. a. true
18. b. false
19. b. false
20. a. true

MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

UNIT I

APPLIANCE ENERGY USE

UNIT OBJECTIVES

1. Appreciate the amount of energy consumed by appliances used in the home.
2. Read appliance labels to determine kilowatt-hour usage.
3. Compute the expense of operating various household appliances.
4. Determine steps to be taken to improve the energy efficiency of home refrigerators and freezers.
5. Discuss energy conservation measures in using cooking appliances.
6. Discuss efficient use of a dishwasher.
7. Discuss laundry appliances and conservation measures for their use.
8. Recognize energy efficiency factors in purchasing and using minor appliances.

MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

UNIT I

APPLIANCE ENERGY USE

LECTURE	ACTIVITIES

INTRODUCTION:

Americans represent approximately 6 percent of the total world population but consume more than 33 percent of the total energy consumed in the world. More than 10 percent of the average American's energy consumption is used for appliances in homes and small businesses. It is estimated that the average American family uses 35,000,000 kilowatts of electricity per hour (KWH) of electricity per year. Ten percent of this would be 350,000 KWH. Rising fuel costs and the disproportionate amount of energy used in the United States raises several questions. Does the United States need the great amount of energy it now uses to maintain its standard of living? Is the energy consumed by the United States being used in ways that assure the most productivity for the amount of energy used? Are all the energy-consuming appliances and devices necessary in the wake of the energy crisis?

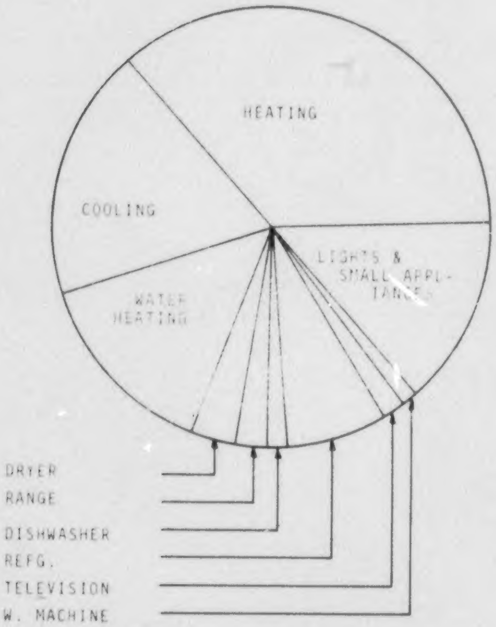
This module will attempt to answer these questions as they apply to household and small commercial appliances. Space heating, space cooling, lighting, and water heating will not be discussed in this module because they have been dealt with in the other modules in this series.

UNIT 1.

APPLIANCE ENERGY USE

Approximately 8 percent of the homeowner's energy usage is to operate electrical home appliances. Electricity for home appliances ranks third in the homeowner's energy use, behind home space heating and cooling and water heating. Heating and cooling a home accounts for 70 percent of the homeowner's energy use while water heating accounts for another 20 percent (Figure 1.1)

AVERAGE ANNUAL KWH
BY APPLIANCE

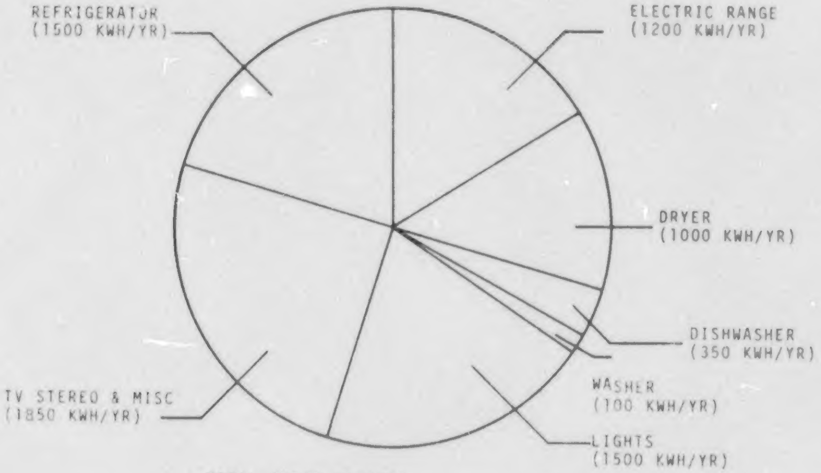


SOURCE: TEXAS POWER & LIGHT COMPANY

FIGURE 1.1

This 8 percent of the homeowner's energy bill to operate electrical home appliances represents approximately 7,500 KWH per year of electrical energy used. (This is for an average family of four). The 7,500 KWH/YR figure can be broken down further by estimating approximately 1,500 KWH/YR of electricity used by the refrigerator; 1,200 KWH/YR used by the electric range; 1,000 KWH/YR used by the electric clothes dryer; 350 KWH/YR by the dishwasher; 100 KWH/YR by the washing machine; 1,500 KWH/YR by lighting; and 1,850 KWH/YR by televisions, stereos, and miscellaneous small appliances. (Figure 1.2)

APPLIANCE AND LIGHTING ENERGY FOR A TYPICAL FOUR-PERSON FAMILY



TOTAL (7500 KWH/YR)

SOURCE: EUGENE ECCLI, LOW-COST, ENERGY-EFFICIENT SHELTER FOR THE OWNER AND BUILDER, 1976.

FIGURE 1.2

The amount of energy used by appliances varies among type, brand and size of appliances; geographic area of use; and the individual use of the appliance. The key to determining the amount of energy an appliance uses is in the wattage of that appliance. An appliance with a wattage rating of 1,000 uses one KWH of electricity for every hour it is in operation. Figure 1.3 shows how much electrical energy an appliance uses in one hour of operation at various wattage ratings, and the approximate amount of oil or coal burned at the power station to produce that amount of electrical energy. By multiplying the customer's cost of one kilowatt of electricity by the KWH of energy used per hour, the cost of one hour's operation can be determined for any appliance in the home.

ELECTRICAL APPLIANCE ENERGY TABLE

APPLIANCE WATTAGE RATING	KILOWATT-HOURS OF ENERGY USED PER HOUR	OUNCES OF OIL BURNED PER HOUR	OUNCES OF COAL BURNED PER HOUR
10	1/100	1/10	13/100
25	1/40	1/4	33/100 (OR 1/3)
40	1/25	2/5	1/2
60	3/50	3/5	4/5
100	1/10	1	1-1/3
150	3/20	1-1/2	2
200	1/5	2	2-2/3
300	3/10	3	4
500	1/2	5	6-2/3
750	3/4	7-1/2	10
1000	1	10	13-1/3
1500	1-1/2	15	20
2000	2	20	26-2/3
5000	5	50	66-2/3

SOURCE: THOMAS ALVA EDISON FOUNDATION

FIGURE 1.3

Figure 1.4 lists a sampling of household appliances and the estimated KWH consumed monthly in using the appliance.

Appliances now in use are larger and more sophisticated than those of the past. Compare, for instance, the size of refrigerators 20 years ago to the size of refrigerators today. Today's refrigerators are built larger, have more features, and, consequently use more energy. The two major uses of appliances in the home--after heating and cooling and water heating--are for refrigeration and food preparation or cooking. When purchasing one of these major appliances, the customer should select a size to meet household requirements. Once purchased, care should be taken to keep the appliance maintained and in top working order.

Using the list in Figure 1.4, inventory your home for the number of appliances in use and add up the total monthly KWH appliance usage. Based on KWH cost for electricity in your area, estimate the monthly and yearly operating cost of each appliance.

For any appliances not listed in Figure 1.4, find the wattage stamped on its registration plate, determine the KWH energy consumption from Figure 1.3, estimate the monthly and annual hourly usage of the appliance, and add it to your list in Figure 1.4.

FOOD PREPARATION	AVERAGE WATTAGE	EST. KWH CONSUMED MONTHLY
Blender	300	0.1
Broiler	1,140	7
Carving Knife	92	0.1
Coffee Maker	1,000	1.0
Crepe Maker	894	9
Deep Fryer	1,448	7
Dishwasher (2 loads)	1,201	30
Double Hamburger Maker	750	.75
Egg Cooker	516	1
Food Processor	360	.17
Frying Pan	1,196	8
Hot Plate	1,200	8
Mixer	127	0.2
Oven, Microwave (only)	1,450	16
Range		
with oven	12,200	98
with self-cleaning oven	12,200	100
Roaster	1,333	5
Trash Compactor	400	2
Waffle Iron	1,200	2
Waste Dispenser	445	2

FOOD PRESERVATION	AVERAGE WATTAGE	EST. KWH CONSUMED MONTHLY
Freezer (15-21 ft.)		
chest type, manual defrost	-	110
upright type		
manual defrost	-	110
automatic defrost	-	165
Refrigerators/Freezers		
manual defrost, 10-15 cu. ft.	-	58
automatic defrost, 16-18 cu. ft.	-	150
automatic defrost, 20 cu. ft. & up	-	158

Food Preservations -- The wattage and consumption of freezers and refrigerators vary according to make and size. Additionally, the electrical consumption is affected by many variables: family size, usage, environment, etc. The table above is merely an estimate based on average equipment and usage. More detailed information about your particular appliance can be obtained through the local Texas Power & Light Company office.

SOURCE: TEXAS POWER & LIGHT COMPANY

FIGURE 1.4

COMFORT CONDITIONING	AVERAGE WATTAGE	EST. KWH CONSUMED HOURLY
Air Cleaner	50	.05
Air Conditioner (room) 12,000 BTU	1,600	1.6
Bed Covering	177	.177
Dehumidifier	257	.257
Fan (attic)	370	.370
Fan (circulating)	88	.088
Fan (rollaway)	171	.171
Fan (window)	200	.200
Furnace Fan	500	.500
Heater (portable)	1,322	1.322
Heating Pad	65	.065
Humidifier	177	.177

Comfort Conditioning -- Since the type and size of comfort conditioning equipment is widely varied, electrical consumption differs greatly from one installation to another. For detailed information about your equipment, its use and consumption, contact the local Texas Power & Light Company office. The above listings are only averages and estimates.

LAUNDRY	WATTAGE AVERAGE	EST. KHW CONSUMED MONTHLY
Clothes Dryer (8 loads per week)	4,856	83
Iron (hand)	1,100	5
Washing Machine (automatic)	512	9
Washing Machine (non-automatic)	286	6
Water Heater	4,500	300-500

FIGURE 1.4 (CONT.)

HOUSEHOLD APPLIANCES (CONT.)

	AVERAGE WATTAGE	EST. KWH CONSUMED MONTHLY
HEALTH & BEAUTY		
Germicidal Lamp	20	12
Hair Dryer	1,000	15
Heat Lamp (infrared)	250	1
Shaver	15	.004
Sun Lamp	275	1
Tooth Brush	1.1	.1
Vibrator	40	.2
HOME ENTERTAINMENT		
Radio (solid state)	10	1
Radio/Record Player	109	9
Television		
Black & white		
Tube type	100	18
Solid state	45	8
Color		
Tube type	240	44
Solid state	145	27
HOUSEWARES		
Clock	2	1.4
Floor Polisher	305	1
Sewing Machine	75	1
Vacuum Cleaner	630	4

FIGURE 1.4 (CONT.)

A. REFRIGERATOR/FREEZER

One of the greatest sources of wasted electricity in a refrigerator or freezer is allowing frost to collect on the evaporator unit. When excessive frost accumulates, the appliance must run for longer periods of time to cool food. This results in wasted energy.

Defrosting should be done before the ice builds up to more than 1/2 inch. Manual defrosting is not an easy chore, but should be done periodically to prolong life of the refrigerator and to cut down on energy use.

Most thermostats in refrigerators and freezers last the lifetime of the appliance. Thermostats can be checked, however, with the use of a thermometer. Place the thermometer on the middle shelf of the compartment and make sure it is not touching any of the food. Close the door and wait 30 minutes; then check the thermometer. If the temperature is higher or lower than 40°F, adjust the temperature setting on the thermostat accordingly. Once satisfied with the temperature of the

Frost-free refrigerators and freezers use more energy for this time-saving feature, but eliminate the task of defrosting manually. Frost-free units have an automatic time clock which periodically turns the cooling unit off and turns on heater strips to melt the ice build-up on the evaporator coils. The heater remains on long enough to melt the frost and ice which then drains into a pan under the condenser.

The refrigerator should be set on 38°F to 40°F for the refrigerator compartment, and 5°F for the freezer section on a refrigerator/freezer combination. Lower settings waste energy by increasing frost build-up; higher settings will save energy but will not keep food properly, thus defeating the purpose of the refrigerator. Separate freezers used to keep food for long periods of time should be set at 0°F.

compartment, remember the control setting for future reference.

Do not hold the door to the unit open for long periods of time. Holding the door open increases frost build-up and reduces efficiency because the warm air entering the unit must be cooled. Check the gasket and seal of the unit periodically. A defective or torn door gasket will allow cool air to escape and warm air to enter the unit. Placing hot food in the refrigerator or freezer compartment also increases frost build-up and forces the unit to remove excess heat.

Place a thermometer inside the refrigerator, close the door, and wait about 15 minutes for the thermometer to reach the inside temperature. Open the door and read the inside temperature. It will probably be about 40°F.

Unplug the refrigerator's power cord from the wall outlet. Keep the door closed for exactly 15 minutes. Open the door and take a temperature reading. The temperature should not have changed.

Plug the refrigerator back in and wait another 15 minutes. Now, unplug the refrigerator again, and repeat the experiment, but every five minutes open the door for about 30 seconds. Check the thermometer after 15 minutes. That's right! The temperature should have risen by several degrees. Explain why.

Usually the refrigerator automatically switches on when warm air enters it, but it has been unplugged to prevent the unit from working.

Keep the condenser well ventilated and clean from dirt and lint build-up. The condenser coil located at the back or on the bottom of the unit allows heat to escape the refrigerator unit. Dust accumulation reduces this condensation and interferes with heat transfer from the coils into the surrounding air. Clean these coils at least twice a year. This could save as much as $1.00 a year on refrigerator operating costs.

Do not block the condenser coils by restricting air circulation. Place the unit away from the wall with no cabinet overhang to interfere with condenser coil fans or air circulation.

A recent feature introduced on refrigerators and freezers is the power-saver switch. Most refrigerators have heating elements in the walls or doors to prevent sweating or humidity build-up on the outside. In most climates, the heating element does not need to be working all the time. The power-saver switch turns off the heating element in dry climatic conditions. By using the power-saver switch, 16 percent of refrigerator energy costs can be saved.

Another item which needs consideration for efficient operation for a refrigerator or freezer is proper wiring. A freezer or refrigerator requires a great deal of electrical current when it first starts up. This sudden surge of power is usually three to four times as much as is required when it is running. Refrigerators require 15 or 20 amps circuits to pre-

Plug the refrigerator back in as before, and wait 30 minutes before you continue the experiment. Meanwhile, fill a bowl or pot with hot water from the kitchen faucet.

After 30 minutes, unplug the refrigerator and place the bowl of water inside. Close the door. In 15 minutes take a temperature reading.

The temperature will have risen several degrees. Explain why.

Check the seal of the unit by closing the door over a dollar bill or a piece of paper so that half of it sticks outside the refrigerator and half remains inside. Pull on the bill. If it pulls out easily, the latch may need adjustment or the seal may need replacing.

vent the brief surges of power from blowing a fuse or circuit breaker. In addition to providing proper circuits, only one large appliance should be plugged into a single circuit. When two or more large appliances--refrigerators, freezers, toaster ovens, irons, grills, microwave ovens--are plugged into the same circuit, the efficiency of each can be reduced greatly and the energy usage strained. This results in each motor working harder for longer periods of time, which shortens the life of the motor. The cord on a freezer or refrigerator is seldom longer than 5 or 6 feet. If an extension cord must be used, be sure to use a heavy-gauge cord. Most inexpensive extension cords are made of 16-gauge wire, which is too small for large appliances. Even 14-gauge wire is too small if the distance from outlet to unit is more than 10 feet. Therefore, it is recommended that 12-gauge wire be used for appliances if the extension cord is longer than 10 feet, and that 14-gauge wire be used for shorter distances. Always use grounded wire and outlets to prevent possible shock.

A. COOKING

The Department of Energy has outlined several tips and energy saving ideas for cooking.

Use cold water rather than hot to operate a food disposer. This saves the energy needed to heat the water, is recommended for the appliance, and aids in getting rid of grease. Grease solidifies in cold water and can be ground up and washed away.

Install an aerator in the kitchen sink faucet. By reducing the amount of water in the flow, less hot water will be used and save the energy that would have been required to heat it. The lower flow pressure is hardly noticeable.

When needing to purchase a gas oven or range, look for one with an automatic (electronic) ignition system instead of pilot lights. An average of up to 47 percent of your gas use--41 percent in the oven and 53 percent on the top burners--will be saved.

If using a gas stove, make sure the pilot light is burning efficiently--with a blue flame. A yellowish flame indicates an adjustment is needed.

Never boil water in an open pan. Water will come to a boil faster and require less energy in a kettle or covered pan.

Keep range-top burners and reflectors clean. They will reflect the heat better, and thus save energy.

Match the size of pan to the heating element. More heat will get to the pan; less will be lost to surrounding air.

Can you think of other energy saving tips for cooking?

Compare the advantages and disadvantages of using a gas range and oven or an electric range and oven in your area. Compare costs. (The KWH usage on electric ranges and the CCF for gas ranges are written on the registration plates.)

What are the advantages or disadvantages of using a conventional electric range to perform several tasks versus a variety of smaller appliances, e.g. a small deep fryer, an electric hot dogger, a toaster oven, an electric water kettle?

If cooking with electricity, get in the habit of turning off the burners several minutes before the allotted cooking time. The heating element will stay hot long enough to finish the cooking without using more electricity.

When using the oven, make the most of the heat from that single source. Cook several foods at one time. Prepare dishes that can be stored or frozen for later or make all oven-cooked meals.

Watch the clock or use a timer; don't continually open the oven door to check food. Every time the door is opened heat escapes, and your cooking takes more energy.

Use small electric pans or ovens for small meals rather than the kitchen range or oven. They use less energy.

Use pressure cookers and microwave ovens, if owned. They can save energy by reducing cooking time.

C. DISHWASHER

The average dishwasher uses 14 gallons of hot water per load. Since the hot water supplied by the home hot water heater is rarely hot enough to sterilize the dishes, a heating element is built in to heat the water to approximately 180°F. After the dishes have been washed and rinsed, this heating element is used to dry the dishes. This means a dishwasher costs the customer twice: once to heat water in the hot water tank, and once in the dishwasher itself to heat the water to a temperature for sterilization. It becomes very important to utilize this appliance efficiently by monitoring its use and insuring it is in good working order.

When installing the dishwasher, size the electric wire properly with the current requirements, as discussed above for refrigerators and freezers.

Insure that hose and water connections are the proper size for the unit so that undue stress and strain on cycle operation does not occur. Proper fittings will reduce wear and prolong the life of the machine.

Clean the food screen often to avoid unnecessary drain clog. If the drain becomes blocked, the motor may overheat causing serious problems.

Check the instructions for the proper water level. An improperly set water level will interfere with the operation of the spray and spinner.

The average dishwasher uses 14 gallons of hot water per load, so use it energy-efficiently.

Be sure the dishwasher is full but not overloaded when it is used.

When buying a dishwasher, look for a model with air-power and/or overnight dry settings. These features automatically turn off the dishwasher after the rinse cycle. This can save up to one-third of total dishwashing energy costs.

Let dishes air dry. If the machine doesn't have an automatic air-dry switch, turn off the control knob after the final rinse. Prop the door open a little and the dishes will dry faster.

Avoid using the "rinse-hold" cycle. It uses 3 to 7 gallons of hot water each time.

Scrape dishes before loading them into the dishwasher to eliminate rinsing. If rinsing is necessary, use cold water.

If every dishwasher user in the country cut out just one load a week, almost 15 million KWH of electricity could be saved every day, or the equivalent of about 9,000 barrels of oil a day.

D. WASHING MACHINE

The washing machine is an important appliance to the American family. It uses both hot water and electricity when it operates, and can waste energy needlessly if the water supply is clogged or if the motor is not properly adjusted.

Periodic inspections or routine maintenance can prolong the life of a washing machine and insure that it is operating most efficiently. Check the motor about once a year. Look for broken or cracked V-belts, defective electrical wiring, oil leaks, and loose connections. Check the hoses and drains to make sure they are not crimped or cracked and are properly tightened. Unscrew the connecting hoses and clean the hose screens of rust particles, dirt, and other obstructions. Remember, a washing machine vibrates during its cycle. This vibration could cause something to work loose and cause it to operate at less than full efficiency.

There are everyday measures to take in using washers which will yield energy savings. First, be conservative with hot water. Second, use the water less frequently by combining or saving up small loads of laundry and making them into larger loads. The Department of Energy suggests other energy saving tips:

Considerable amounts of energy can be saved in the laundry through conservation of hot water and by using automatic washers and dryers less often and more efficiently.

Wash clothes in warm or cold water, rinse in cold, thus saving energy and money. Use hot water only if absolutely necessary.

Fill washers (unless they have small-load attachments or variable water levels), but do not overload.

Use the suds-saver if the washer has this feature. It will allow use of one tubful of hot water for several loads of clothes.

Don't use too much detergent. Follow the instructions on the box. Oversudsing makes machines work harder and use more energy.

Pre-soak or use a soak cycle when washing heavily soiled garments. Avoid two washings and save energy.

E. CLOTHES DRYER

Clothes dryers are either all-electric or gas with an electric motor. The purpose of the dryer is to evaporate the water held in wet clothes. This is done by air passing over the clothes and out the vent. Electric dryers use a heating element to warm the air drawn into the dryer. Gas dryers use heated exhaust gas, ignited by an electric spark or hot-wire starter, to dry the clothes. A series of thermostats monitor the temperature of the air entering and leaving the dryer controls. Some dryers have an electronic humidity sensor which determines when the clothes reach a desired amount of dryness. This sensor controls the temperature of the dryer so the clothes will not wrinkle.

Once the moisture has evaporated from the clothes the dryer will be wasting energy if it is allowed to continue operating. The timer should be set to coincide as closely as possible with the actual amount of time required to dry the clothes.

Clothes dryers often have several drying temperatures and a variety of time settings for various materials. The correct combination of time and temperature setting for certain fabrics gives the most efficient use of the required energy. To accomplish this requires practice and some experimenting.

Below are some energy saving tips for efficient operation of clothes dryers:

- Fill clothes dryers but do not overload.

Put a load of clothes in the dryer, and begin watching the clock. After 15 minutes, open the dryer door, and feel the clothes. They will probably still be damp. Close the door, and restart the dryer.

Do this again every five minutes until the clothes feel dry to the touch. Look at the timer and see how much longer the dryer was set to run. If the dryer is electric, every wasted minute burned up about 4/5-ounce of oil (or one ounce of coal) at the power company. If the dryer runs on gas, every wasted minute burns about 1/10 cubic feet of gas. Multiply this by the number of dryer loads a year to get the annual amount of wasted energy you pay for.

- Keep the lint screen in the dryer clean. Remove lint after each load. Lint impedes the flow of air in the dryer and requires the machine to use more energy.

- Keep the outside exhaust of the clothes dryer clean. Check it regularly. A clogged exhaust lengthens the drying time and increases the amount of energy used.

- If the dryer has an automatic dry cycle, use it. Overdrying merely wastes energy.

- Dry clothes in consecutive loads beginning with a load requiring the hottest setting. Stop-and-start drying uses more energy because a lot goes into bringing the dryer up to the desired temperature each time you begin.

- Separate drying loads into heavy and lightweight items. Since the lighter ones take less drying time, the dryer doesn't have to be on as long for these loads.

- If drying the family wash takes more than one load, leave small, lightweight items until last. You may be able to turn off the power and dry them with heat retained by the machine from earlier loads.

- Save energy by using the old-fashioned clothesline. As a bonus, clothes dried outdoors often seem fresher and cleaner than those taken from a mechanical dryer.

F. MINOR APPLIANCES

The appliances discussed up to this point have been major appliances which serve a necessary function in the home. The energy saving tips have included maintenance for efficient operation and selective use. In addition to major appliances, there are approximately 30 small electric appliances which make the work at home convenient. Some of these "gadgets" are necessary and helpful, but others are more convenient than efficient and waste a great deal of energy. Some small appliances could be eliminated by substituting simple human energy as a power source rather than electrical energy. This topic is controversial and individuals will argue the merit of some small appliances over the alternate of manual labor. The point still exists, however, that the appliances costs money to operate. Is the user of the product willing or prepared to pay the price to operate them?

Figure 1.5 lists some small appliances which could be eliminated by substituting non-energy consuming means. The annual amount of KWH consumed by each appliance is also listed.

Some of these figures are not large. Others add up substantially. The use of such appliances adds to the 33 percent total world energy used by the 6 percent of the world population which lives in the United States.

From the lists made from Figures 1.3 and 1.4, identify those appliances you feel are unnecessary. How frequently are they used? Can you determine how much energy and money can be saved by eliminating them?

ELIMINATING UNNECESSARY APPLIANCES

Electric Appliances	Kilowatt Hours Consumed Annually	Substitute
Blender	15	EGG BEATER AND STRONG ARM
Carving knife	8	SHARP KNIFE
Coffee maker	106	DO WITHOUT
Dishwasher	363	WASH DISHES BY HAND
Egg cooker	14	COOK EGGS IN BOILING WATER USED FOR TEA OR COFFEE
Garbage disposal	30	COMPOST FOOD WASTE
Trash compactor	50	MANUALLY SHRED TRASH AND CRUSH CANS
Clothes dryer	993	HANG CLOTHES TO DRY OUTSIDE IN SUMMER AND INSIDE IN WINTER (TO HELP HUMIDIFY)
Iron	144	WEAR PERMANENT-PRESS CLOTHING
Electric blanket	147	SLEEP WITH EXTRA BLANKETS
Humidifier	163	PUT A PAN OF WATER ON THE RADIATOR, HANG UP WET CLOTHES, OR OPEN THE BATHROOM DOOR AFTER A SHOWER
Portable heater	176	HEAVIER CLOTHING
Hair dryer	14	DRY TOWEL, STRONG ARMS
Germicidal lamp	141	DO WITHOUT
Sun lamp	16	GO OUTSIDE AND ENJOY THE SUNSHINE
Shaver	1.8	GROW A BEARD
Toothbrush	.5	BRUSH BY HAND
Vibrator	2	PHYSICAL EXERCISE
Clock	17	WIND-UP CLOCK
Can opener		MANUAL CAN OPENER
Lawn mower		HAND-POWERED MOWER
Hedge clipper		HAND-POWERED CLIPPER
Saw		HAND-POWERED SAW
Paint mixer		HAND-POWERED MIXER

SOURCE: CENTER FOR SCIENCE IN THE PUBLIC INTEREST

FIGURE 1.5

G. APPLIANCE ENERGY CONSERVATION TIPS

To summarize tips on how to save energy when buying or using appliances, here are a few general ideas to consider from the Department of Energy.

1. Don't leave appliances running when not in use. It's a total waste of energy. Remember to turn off a radio, TV, or record player when leaving a room.

2. Keep appliances in good working order so they will last longer, work more efficiently, and use less energy.

3. When buying appliances, comparison shop. Compare energy use information and operating costs of similar models by the same and different manufacturers. The retailer should be able to help find the wattage of the appliance. With that information, figure out how much it will cost to run the appliance chosen.

4. Before buying new appliances with special features, find out how much energy they use compared with other, perhaps less convenient, models. A frost-free refrigerator, for example, uses more energy than a manual-defrost model. It also costs more to purchase. The energy and dollars saved with a manual-defrost model may make up giving up the convenience.

5. Use appliances wisely; use the one that takes the least amount of energy for the job. For example: toasting bread in the oven uses three times more energy than toasting in a toaster.

6. Don't use energy-consuming special features on appliances if there is an alternative. For example, don't use the "instant-on" feature of a TV set. "Instant-on" sets, especially the tube types, use energy even when the screen is dark. Use the "vacation switch," if there is one, to eliminate this waste; plug the set into an outlet that is controlled by a wall switch; or have the TV servicer install an additional on-off switch on the set itself or in the cord to the wall outlet.

MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

UNIT II

THE APPLIANCE LABELING PROGRAM

UNIT OBJECTIVES

1. Discuss the appliance labeling program established by Congress.
2. Discuss the advantages and disadvantages of the Federal Trade Commission's labeling program.

MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

UNIT II

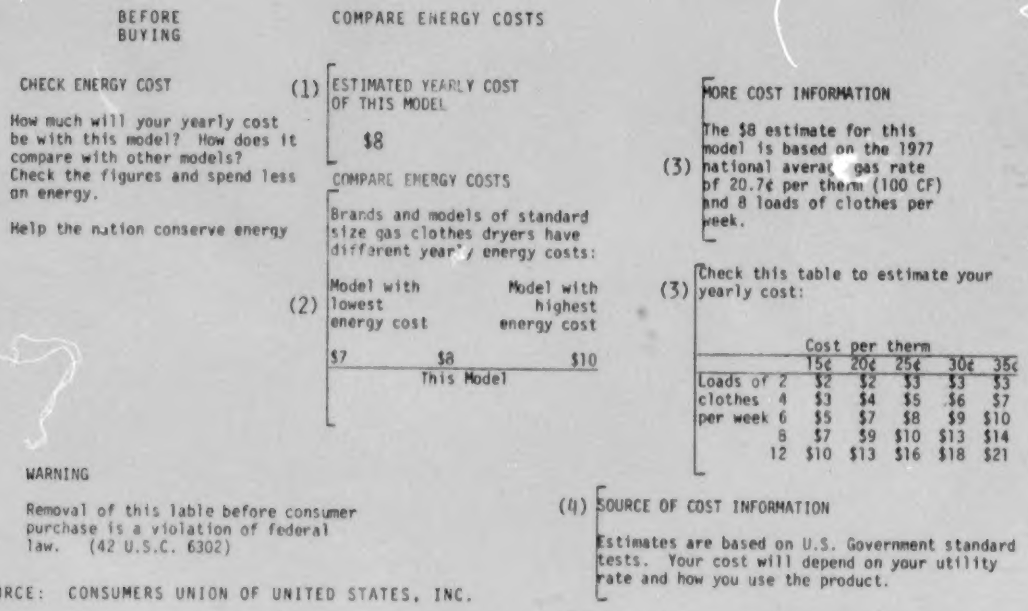
THE APPLIANCE LABELING PROGRAM

LECTURE	ACTIVITIES
On December 22, 1975, the Energy Policy and Conservation Act enacted a law that established a labeling program designed to help consumers shop for energy-saving household appliances and equipment. The Federal Trade Commission and the Department of Energy are developing the procedures for appliance testing, labeling, and public information required by this law. These procedures and appliance labels began showing on the market in the fall of 1979. The program is aimed at a variety of appliances that together account for roughly 90 percent of the energy used in the home. The appliances include clothes dryers, washing machines, refrigerators, freezers, ranges, television sets, humidifiers, water heaters, furnaces, dishwashers, and air-conditioners. Eventually, the program will have a direct effect on the design of appliances, since the Department of Energy will set mandatory energy-efficiency standards. At first, however, the program affects only the way appliances are advertised and marketed, and require appliances to carry a label listing annual energy costs.	

As proposed, the labels highlight the estimated annual operating cost for each appliance brand and model. The estimate is based on national average ranges of energy prices and on patterns of "typical" use. Finally, a chart shows how a specific model's energy cost compares with that of competing models. This is followed by a disclaimer noting that actual costs will vary.

A sample energy label is at Figure 2.1 below. Some of the labels are small and reasonably straightforward, but others--notably those for humidifiers--are very elaborate.

FEDERAL TRADE COMMISSION'S PROPOSED APPLIANCE LABEL



BEFORE
BUYING

CHECK ENERGY COST

How much will your yearly cost be with this model? How does it compare with other models? Check the figures and spend less on energy.

Help the nation conserve energy

COMPARE ENERGY COSTS

(1) ESTIMATED YEARLY COST OF THIS MODEL

$8

COMPARE ENERGY COSTS

Brands and models of standard size gas clothes dryers have different yearly energy costs:

(2) Model with lowest energy cost — Model with highest energy cost

$7 — $8 — $10

This Model

MORE COST INFORMATION

(3) The $8 estimate for this model is based on the 1977 national average gas rate of 20.7¢ per therm (100 CF) and 8 loads of clothes per week.

(3) Check this table to estimate your yearly cost:

		Cost per therm				
		15¢	20¢	25¢	30¢	35¢
Loads of	2	$2	$2	$3	$3	$3
clothes	4	$3	$4	$5	$6	$7
per week	6	$5	$7	$8	$9	$10
	8	$7	$9	$10	$13	$14
	12	$10	$13	$16	$18	$21

WARNING

Removal of this lable before consumer purchase is a violation of federal law. (42 U.S.C. 6302)

(4) SOURCE OF COST INFORMATION

Estimates are based on U.S. Government standard tests. Your cost will depend on your utility rate and how you use the product.

SOURCE: CONSUMERS UNION OF UNITED STATES, INC.

FIGURE 2.1

FEDERAL TRADE COMMISION'S PROPOSED APPLIANCE LABEL

THE FTC'S PROPOSED APPLIANCE LABELS WOULD PROVIDE INFORMATION ABOUT ENERGY COSTS IN VARIOUS WAYS, AS SHOWN IN THIS HYPOTHETICAL LABEL.

1. THE ESTIMATED YEARLY COST FIGURE GIVES YOU ONE MORE FACTOR TO USE IN CHOOSING AN APPLIANCE. ALL OTHER THINGS BEING EQUAL, AN APPLIANCE THAT HAS A HIGH PRICE BUT A RELATIVELY LOW OPERATING COST MIGHT BE A BETTER BARGAIN THAN A LOW-PRICED MODEL WITH A HIGH OPERATING COST.

2. TO SHOW HOW A SPECIFIC MODEL STACKS UP AGAINST THE COMPETITION, THE LABEL WOULD COMPARE OPERATING COSTS FOR SIMILAR MODELS. IF THE RANGE IS FAIRLY NARROW (AS IT IS WITH GAS DRYERS, SHOWN HERE), YOU MIGHT NOT NEED TO USE THE LABEL INFORMATION.

3. BECAUSE FEW PEOPLE PAY NATIONAL AVERAGE ENERGY PRICES, AND BECAUSE PATTERNS OF USE VARY, THE LABELS WOULD GIVE A RANGE OF ESTIMATED COSTS FOR EACH MODEL.

4. AN IMPORTANT REMINDER: THE ESTIMATES ON THE LABELS MAY NOT REFLECT YOUR ACTUAL COSTS, BUT THEY MAY ALLOW YOU TO PICK OUT THE RELATIVELY EFFICIENT APPLIANCES. KEEP IN MIND, ALSO, THAT THE ENERGY-COST ESTIMATES ON THE LABEL INDICATE NOTHING ABOUT THE PERFORMANCE, CONVENIENCE, SAFETY, OR DURABILITY OF A PARTICULAR APPLIANCE.

FIGURE 2.1 (CONT.)

The labels are intended to allow the customer to compare operating cost as well as price when shopping for an appliance. Government officials hope the labels will thereby add an extra element of competition to the marketplace, thus prodding manufacturers to design products that are more energy-efficient.

The appliance industry is far from pleased with the FTC's labeling regulations. Many manufacturers believe that the figures on the labels could mislead consumers because no two homes use an appliance in the same way and because utility rates are changing. Therefore, it is impossible to set any meaningful estimate for the cost of operation. Others are concerned that the promotional exploitation of data based on the energy testing program may lead some people to believe that the appliances have been tested for performance, convenience, safety, durability, or some other factor not involved with energy. In addition, some critics claim the labels will not help much because the operating cost figures will vary only slightly from one appliance to another. Therefore, labels will be most useful when they show a fairly wide range of energy costs.

In addition to labels and advertising, the government is taking a direct approach to energy conservation by imposing mandatory minimum efficiency standards on the appliance industry. The standards, which should be put in final form within three years, will supplant a set of voluntary "improvement targets" mandated by the 1975 energy law.

Many industry representatives may have to stop making certain appliance models if the standards are too difficult or costly to meet. However, the disappearance of inefficient appliances should still leave plenty of room for consumer choice.

The upcoming government standards, along with the labeling program, are likely to mean higher list prices for appliances. Exactly how much higher is not certain at this point, but some early Department of Energy estimates show design changes called for under the voluntary target program will have added about $45 to the price of a refrigerator, for example, and about $60 to the price of a room air-conditioner. In theory, however, the customer could recover such price increases through lower annual operating costs, assuming the efficiency improvements do not shorten the useful life of the product or increase the need to service it.

MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

POSTTEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. An appliance with a wattage rating of 1000 uses 2 KWH of electricity for every hour it is in operation.

   a. true   b. false

2. Nearly 8 percent of the homeowner's energy usage is to operate electrical home appliances.

   a. true   b. false

3. The American population consumes 33 percent of the total energy consumed in the world.

   a. true   b. false

4. The wattage of an automatically defrosting refrigerator is more than that of the refrigerator that requires manual defrosting.

   a. true   b. false

5. The wattage requirement of a microwave oven is less than that of the oven of a range.

   a. true   b. false

6. The two major uses of appliances in the home...after heating and cooling and hot water heating...are for refrigeration and cooking.

   a. true   b. false

7. The cost of one hour's operation can be determined for any appliance by multiplying the customer's cost of one kilowatt of electricity by the KWH of energy used per hour.

   a. true   b. false

8. The refrigerator should be set on a temperature between 38°F and 40°F.

   a. true   b. false

9. Water will come to a boil faster and require less energy in a covered pan than in an open pan.

   a. true   b. false

10. A freezer or refrigerator requires very little electric current when it furst starts up.

    a. true b. false

11. It is true that a pressure cooker will cost you money for energy that is excessive.

    a. true b. false

12. A dishwasher must heat the water that comes to it from the water heater.

    a. true b. false

13. A refrigerator will run for a shorter period of time when excessive frost accumulates on the evaporator unit.

    a. true b. false

14. It is economical to allow your dishwasher to dry your dishes.

    a. true b. false

15. Using a lot of detergent in your washer will cause the machine to use less energy.

    a. true b. false

16. Lint on the lint screen of your dryer will cause the machine to use less energy.

    a. true b. false

17. Poorly maintained appliances will require more energy for their operation than appliances kept in good working condition.

    a. true b. false

18. An electric clock uses very little energy.

    a. true b. false

19. A tube television set requires more energy for its operation than a solid state television set.

    a. true b. false

20. The FTC's appliance labels do not provide information about energy costs.

    a. true b. false

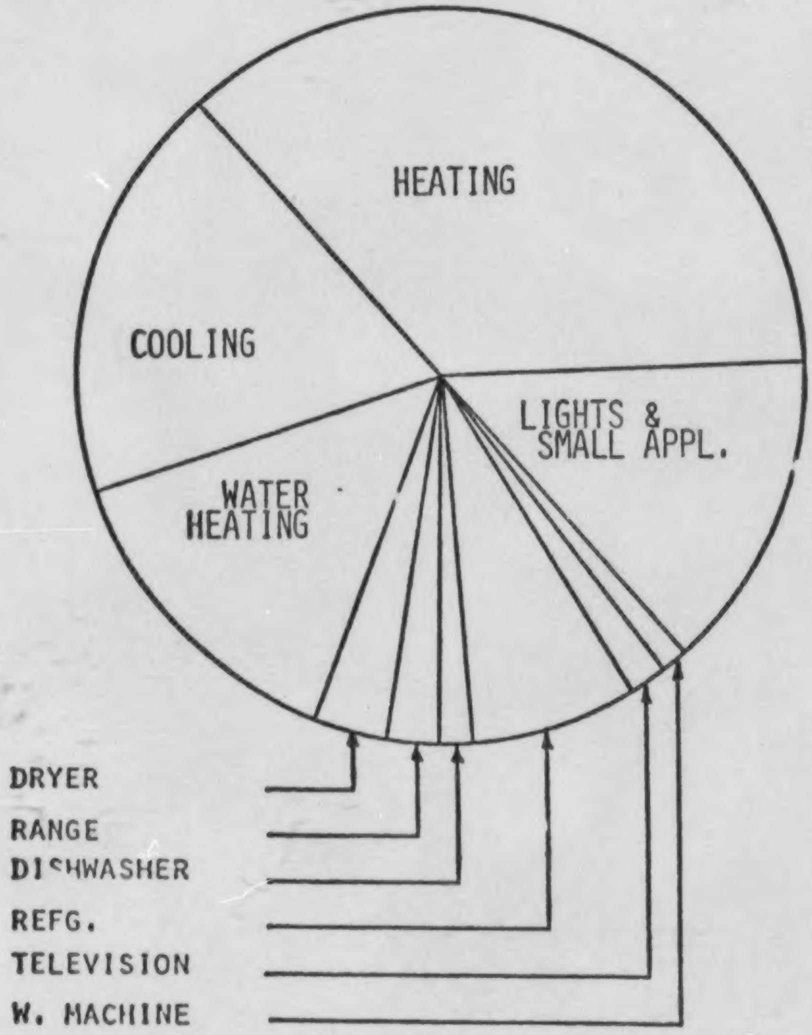
MODULE VII

APPLIANCE ENERGY CONSERVATION OPPORTUNITIES

ANSWERS TO POSTTEST

1. b. false
2. a. true
3. a. true
4. a. true
5. a. true
6. a. true
7. a. true
8. a. true
9. a. true
10. b. false
11. b. false
12. a. true
13. b. false
14. b. false
15. b. false
16. b. false
17. a. true
18. a. true
19. a. true
20. b. false

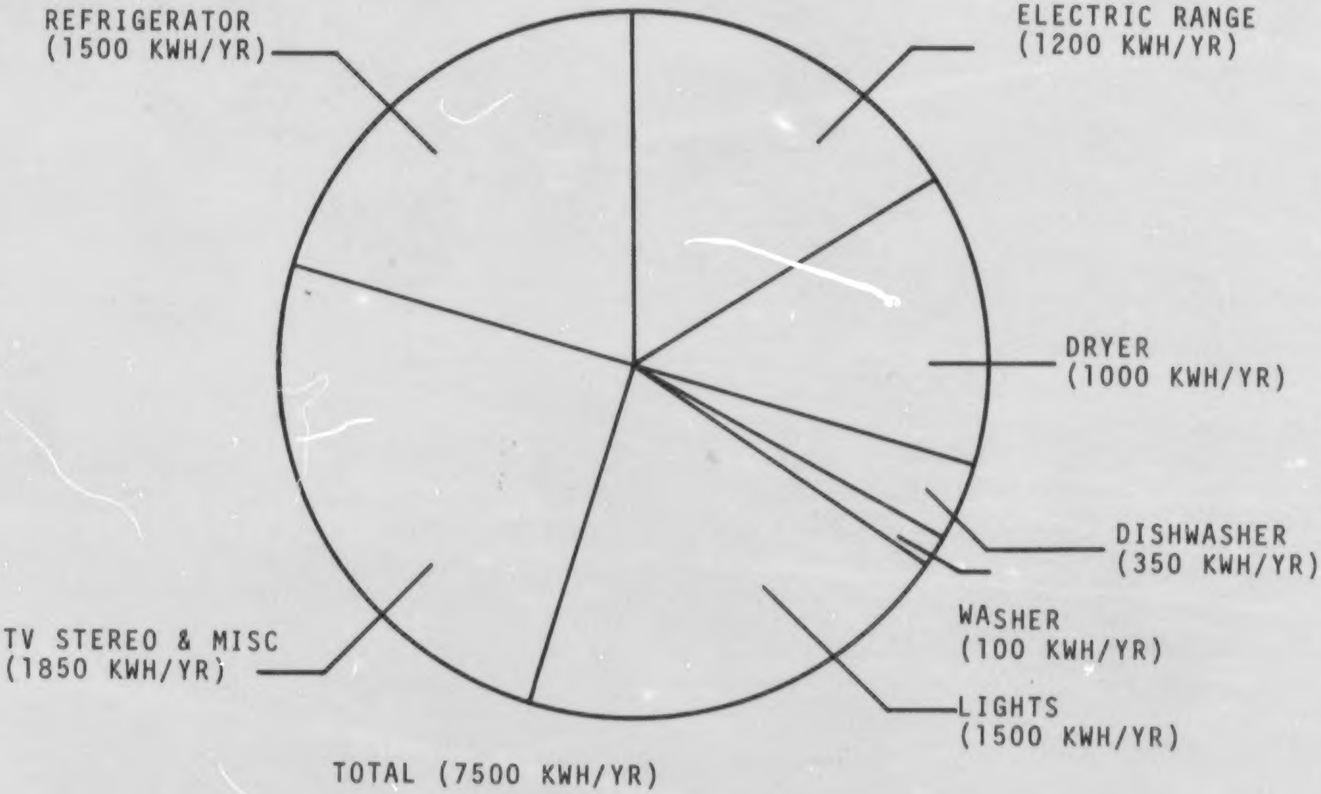
AVERAGE ANNUAL KWH
BY APPLIANCE



SOURCE: Texas Power and Light Company

FIGURE 1.1

APPLIANCE AND LIGHTING ENERGY FOR A TYPICAL FOUR-PERSON FAMILY



SOURCE: EUGENE ECCLI, LOW-COST, ENERGY-EFFICIENT SHELTER FOR THE OWNER AND BUILDER, 1976.

FIGURE 1.2

ELECTRICAL APPLIANCE ENERGY TABLE

APPLIANCE WATTAGE RATING	KILOWATT-HOURS OF ENERGY USED PER HOUR	OUNCES OF OIL BURNED PER HOUR	OUNCES OF COAL BURNED PER HOUR
10	1/100	1/10	13/100
25	1/40	1/4	33/100 (OR 1/3)
40	1/25	2/5	1/2
60	3/50	3/5	4/5
100	1/10	1	1-1/3
150	3/20	1-1/2	2
200	1/5	2	2-2/3
300	3/10	3	4
500	1/2	5	6-2/3
750	3/4	7-1/2	10
1000	1	10	13-1/3
1500	1-1/2	15	20
2000	2	20	26-2/3
5000	5	50	66-2/3

SOURCE: THOMAS ALVA EDISON FOUNDATION

FIGURE 1.3

HOUSEHOLD APPLIANCES

FOOD PREPARATION	AVERAGE WATTAGE	EST. KWH CONSUMED MONTHLY
BLENDER	300	0.1
BROILER	1,140	7
CARVING KNIFE	92	0.1
COFFEE MAKER	1,000	1.0
CREPE MAKER	894	9
DEEP FRYER	1,448	7
DISHWASHER (2 LOADS)	1,201	30
DOUBLE HAMBURGER MAKER	750	.75
EGG COOKER	516	1
FOOD PROCESSOR	360	.17
FRYING PAN	1,196	8
HOT PLATE	1,200	8
MIXER	127	0.2
OVEN, MICROWAVE (ONLY)	1,450	16
RANGE		
WITH OVEN	12,200	98
WITH SELF-CLEANING OVEN	12,200	100
ROASTER	1,333	5
TRASH COMPACTOR	400	2
WAFFLE IRON	1,200	2
WASTE DISPENSER	445	2

SOURCE: TEXAS POWER & LIGHT COMPANY

FIGURE 1.4

HOUSEHOLD APPLIANCES (CONT.)

COMFORT CONDITIONING	AVERAGE WATTAGE	EST. KWH CONSUMED HOURLY
AIR CLEANER	50	.05
AIR CONDITIONER (ROOM) 12,000 BTU	1,600	1.6
BED COVERING	177	.177
DEHUMIDIFIER	257	.257
FAN (ATTIC)	370	.370
FAN (CIRCULATING)	88	.088
FAN (ROLLAWAY)	171	.171
FAN (WINDOW)	200	.200
FURNACE FAN	500	.500
HEATER (PORTABLE)	1,322	1.322
HEATING PAD	65	.065
HUMIDIFIER	177	.177

COMFORT CONDITIONING -- SINCE THE TYPE AND SIZE OF COMFORT CONDITIONING EQUIPMENT IS WIDELY VARIED, ELECTRICAL CONSUMPTION DIFFERS GREATLY FROM ONE INSTALLATION TO ANOTHER. FOR DETAILED INFORMATION ABOUT YOUR EQUIPMENT, ITS USE AND CONSUMPTION, CONTACT THE LOCAL TEXAS POWER & LIGHT COMPANY OFFICE. THE ABOVE LISTINGS ARE ONLY AVERAGES AND ESTIMATES.

FIGURE 1.4 (CONT.)

HOUSEHOLD APPLIANCES (CONT.)

FOOD PRESERVATION	AVERAGE WATTAGE	EST. KWH CONSUMED MONTHLY
FREEZER (15-21 FT.)		
CHEST TYPE, MANUAL DEFROST	-	110
UPRIGHT TYPE		
MANUAL DEFROST	-	110
AUTOMATIC DEFROST	-	165
REFRIGERATORS/FREEZERS		
MANUAL DEFROST, 10-15 CU. FT.	-	58
AUTOMATIC DEFROST, 16-18 CU. FT.	-	150
AUTOMATIC DEFROST, 20 CU. FT. & UP	-	158

FOOD PRESERVATIONS -- THE WATTAGE AND CONSUMPTION OF FREEZERS AND REFRIGERATORS VARY ACCORDING TO MAKE AND SIZE. ADDITIONALLY, THE ELECTRICAL CONSUMPTION IS AFFECTED BY MANY VARIABLES: FAMILY SIZE, USAGE, ENVIRONMENT, ETC. THE TABLE ABOVE IS MERELY AN ESTIMATE BASED ON AVERAGE EQUIPMENT AND USAGE. MORE DETAILED INFORMATION ABOUT YOUR PARTICULAR APPLIANCE CAN BE OBTAINED THROUGH THE LOCAL TEXAS POWER & LIGHT COMPANY OFFICE.

FIGURE 1.4 (CONT.)

HOUSEHOLD APPLIANCES (CONT.)

	AVERAGE WATTAGE	EST. KWH CONSUMED MONTHLY
HEALTH & BEAUTY		
Germicidal Lamp	20	12
Hair Dryer	1,000	15
Heat Lamp (infrared)	250	1
Shaver	15	.004
Sun Lamp	275	1
Tooth Brush	1.1	.1
Vibrator	40	.2
HOME ENTERTAINMENT		
Radio (solid state)	10	1
Radio/Record Player	109	9
Television		
Black & White		
Tube Type	100	18
Solid State	45	8
Color		
Tube Type	240	44
Solid State	145	27
HOUSEWARES		
Clock	2	1.4
Floor Polisher	305	1
Sewing Machine	75	1
Vacuum Cleaner	630	4

FIGURE 1.4 (CONT.)

HOUSEHOLD APPLIANCES (CONT.)

LAUNDRY	WATTAGE AVERAGE	EST. KHW CONSUMED MONTHLY
CLOTHES DRYER (8 LOADS PER WEEK)	4,856	83
IRON (HAND)	1,100	5
WASHING MACHINE (AUTOMATIC)	512	9
WASHING MACHINE (NON-AUTOMATIC)	286	6
WATER HEATER	4,500	300-500

FIGURE 1.4 (CONT.)

ELIMINATING UNNECESSARY APPLIANCES

Electric Appliances	Kilowatt Hours Consumed Annually	Substitute
Blender	15	EGG BEATER AND STRONG ARM
Carving knife	8	SHARP KNIFE
Coffee maker	106	DO WITHOUT
Dishwasher	363	WASH DISHES BY HAND
Egg cooker	14	COOK EGGS IN BOILING WATER USED FOR TEA OR COFFEE
Garbage disposal	30	COMPOST FOOD WASTE
Trash compactor	50	MANUALLY SHRED TRASH AND CRUSH CANS
Clothes dryer	993	HANG CLOTHES TO DRY OUTSIDE IN SUMMER AND INSIDE IN WINTER (TO HELP HUMIDIFY)
Iron	144	WEAR PERMANENT-PRESS CLOTHING
Electric blanket	147	SLEEP WITH EXTRA BLANKETS
Humidifier	163	PUT A PAN OF WATER ON THE RADIATOR, HANG UP WET CLOTHES, OR OPEN THE BATHROOM DOOR AFTER A SHOWER
Portable heater	176	HEAVIER CLOTHING
Hair dryer	14	DRY TOWEL, STRONG ARMS
Germicidal lamp	141	DO WITHOUT
Sun lamp	16	GO OUTSIDE AND ENJOY THE SUNSHINE
Shaver	1.8	GROW A BEARD
Toothbrush	.5	BRUSH BY HAND
Vibrator	2	PHYSICAL EXERCISE
Clock	17	WIND-UP CLOCK
Can opener		MANUAL CAN OPENER
Lawn mower		HAND-POWERED MOWER
Hedge clipper		HAND-POWERED CLIPPER
Saw		HAND-POWERED SAW
Paint mixer		HAND-POWERED MIXER

SOURCE: CENTER FOR SCIENCE IN THE PUBLIC INTEREST

FIGURE 1.5

FEDERAL TRADE COMMISSION'S PROPOSED APPLIANCE LABEL

BEFORE
BUYING

COMPARE ENERGY COSTS

CHECK ENERGY COST

How much will your yearly cost be with this model? How does it compare with other models? Check the figures and spend less on energy.

Help the nation conserve energy

(1) ESTIMATED YEARLY COST
OF THIS MODEL

$8

COMPARE ENERGY COSTS

(2) Brands and models of standard size gas clothes dryers have different yearly energy costs:

Model with lowest energy cost		Model with highest energy cost
$7	$8	$10
	This Model	

(3) MORE COST INFORMATION

The $8 estimate for this model is based on the 1977 national average gas rate of 20.7¢ per therm (100 CF) and 8 loads of clothes per week.

(3) Check this table to estimate your yearly cost:

		Cost per therm				
		15¢	20¢	25¢	30¢	35¢
Loads of	2	$2	$2	$3	$3	$3
clothes	4	$3	$4	$5	$6	$7
per week	6	$5	$7	$8	$9	$10
	8	$7	$9	$10	$13	$14
	12	$10	$13	$16	$18	$21

WARNING

Removal of this lable before consumer purchase is a violation of federal law. (42 U.S.C. 6302)

(4) SOURCE OF COST INFORMATION

Estimates are based on U.S. Government standard tests. Your cost will depend on your utility rate and how you use the product.

SOURCE: CONSUMERS UNION OF UNITED STATES, INC.

FIGURE 2.1

FEDERAL TRADE COMMISION'S PROPOSED APPLIANCE LABEL

THE FTC'S PROPOSED APPLIANCE LABELS WOULD PROVIDE INFORMATION ABOUT ENERGY COSTS IN VARIOUS WAYS, AS SHOWN IN THIS HYPOTHETICAL LABEL.

1. THE ESTIMATED YEARLY COST FIGURE GIVES YOU ONE MORE FACTOR TO USE IN CHOOSING AN APPLIANCE. ALL OTHER THINGS BEING EQUAL, AN APPLIANCE THAT HAS A HIGH PRICE BUT A RELATIVELY LOW OPERATING COST MIGHT BE A BETTER BARGAIN THAN A LOW-PRICED MODEL WITH A HIGH OPERATING COST.

2. TO SHOW HOW A SPECIFIC MODEL STACKS UP AGAINST THE COMPETITION, THE LABEL WOULD COMPARE OPERATING COSTS FOR SIMILAR MODELS. IF THE RANGE IS FAIRLY NARROW (AS IT IS WITH GAS DRYERS, SHOWN HERE), YOU MIGHT NOT NEED TO USE THE LABEL INFORMATION.

3. BECAUSE FEW PEOPLE PAY NATIONAL AVERAGE ENERGY PRICES, AND BECAUSE PATTERNS OF USE VARY, THE LABELS WOULD GIVE A RANGE OF ESTIMATED COSTS FOR EACH MODEL.

4. AN IMPORTANT REMINDER: THE ESTIMATES ON THE LABELS MAY NOT REFLECT YOUR ACTUAL COSTS, BUT THEY MAY ALLOW YOU TO PICK OUT THE RELATIVELY EFFICIENT APPLIANCES. KEEP IN MIND, ALSO, THAT THE ENERGY-COST ESTIMATES ON THE LABEL INDICATE NOTHING ABOUT THE PERFORMANCE, CONVENIENCE, SAFETY, OR DURABILITY OF A PARTICULAR APPLIANCE.

FIGURE 2.1 (CONT.)

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. Building Construction Versus Energy Consumption may be offered independently, or as part of a sequence of three modules in the following order:

Order	Module	Title of Module
1	8	Building Construction Versus Energy Consumption
2	10	Heating, Ventilating, and Air Conditioning Conservation Opportunities
3	11	Economics of Energy Conservation

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

MODULE DESCRIPTION:

This module discusses heat transfer in buildings, including heat conduction, convection, radiation, and evaporation. Heat loss and heat gain characteristics and values are discussed in terms of air infiltration, glazing, insulation, and thermal mass. Building site selection, orientation, and shading, as well as building codes and regulations, are presented as considerations necessary prior to construction.

Calculating heat loss and gain while utilizing weather data and discussing cost and benefit analysis of conservation opportunities makes up a major portion of this module. A student workbook for surveying heat loss and heat gain in a home is provided along with formulas to determine costs and savings for implementing certain energy conservation measures.

GOAL STATEMENT:

The objective of this module is to train secondary and postsecondary students in the recognition, implementation, and utilization of energy consumption, and possible conservation in building construction and design.

READING GRADE LEVELS:

Lecture: : 12
Student Workbook: 10

SUGGESTED TEACHING TIMES:

Secondary : 5 hours
Postsecondary: 3 hours

UNITS:

- I. Construction Considerations Before Building
  - A. Home Energy Consumption
  - B. Home Energy Conservation Potential
  - C. Methods of Transferring Heat
  - D. Building Codes
- II. Building Site and Design
  - A. Orientation
  - B. Glazing
  - C. Insulation
    - 1. The K Factor
    - 2. The U Factor
    - 3. The R Factor
    - 4. Types of Insulation
  - D. Walls
  - E. Ceilings
  - F. Shading Devices
  - G. Building Mass
- III. Weatherization
  - A. Windows
  - B. Doors
  - C. Caulking
  - D. Energy Conservation Measures
    - 1. During the Heating Season
    - 2. During the Cooling Season

Student Weatherization Workbook

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

TERMINOLOGY

British thermal unit (Btu)--a measurement of heat energy. The amount of heat energy required to raise the temperature of one pound of water one degree Farenheit. Furnaces and air conditioners are sized in British thermal units.

Condensation--water that forms from water vapor in the air. When the temperature of the air drops, some of the water vapor in the air will change into water.

Conduction--a method of heat transfer. Heat is transferred when a warm object touches a cool object. The term also refers to the passage of electrical current.

Convection--a method of heat transfer. Moving air picks up heat from nearby objects and transfers it to cool objects.

Cooling load--also called heat gain--the amount of heat energy that enters a structure during the cooling season.

Degree-day--a measure that expresses the average temperature difference relative to 65°F during a 24-hour day. If a certain day has an average temperature of 30°F, the degree days would be 35. Degree-days are used to calculate heating and cooling loads and building requirements.

Design temperature--the hottest or coldest temperature in an area. Used for sizing heating and air conditioning systems.

Effect temperature--the total effect on the comfort of the human body of air movement, humidity, and temperature.

Evaporation--the process of a liquid changing to a gas. Water changing into water vapor is an example of evaporation.

Heat gain--the amount of heat energy that enters the house from outside sources. Usually used in reference to summer cooling, but additional heat from outside sources during the winter is also heat gain. Often called cooling load.

Heat load--also called heat loss--the amount of heat lost through the structure of a building. Heat loads are measured in Btu per hour.

Heat loss--see heat load.

Heat transfer--the movement of heat energy.

Infiltration air--air that comes into a house unintentionally through cracks and openings in the structure.

Insulating glass--windows with two panes of glass sealed together in one sash. The extra air space between the panes reduces the heat flow through the window area.

Insulation--material that does not readily conduct heat energy.

Jamb--the top and sides of a door or window frame that make contact with the door or the sash.

Joists--the parallel framing boards that support the floor and ceiling. Joists run horizontally.

K factor--a number indicating the amount of heat energy that will pass through a material; also called the conductivity factor.

Loose-fill insulation--insulation that is sold in a sack and poured into place.

Mineral wool--a material used to make insulation, including loose-fill and batting insulation.

Polystyrene--a closed-cell, plastic foam insulation with a high thermal resistance.

Radiation--a method of heat transfer. Infrared rays warm an object without contact from objects or air.

R factor--the resistance of a material or an entire wall to the flow of heat. Insulation is rated in R values to show its resistance to heat flow.

Sash--the frame holding the glass in a window.

Sheathing--the boards that cover the framing of the walls and roof of a structure.

Solar heat--Heat from the sun.

Solar load--the number of Btu added to the cooling load of the structure by the sun.

Studs--the parallel vertical boards (usually 2 x 4s) that form the wall supports of a structure.

Subfloor--the boards laid on top of the floor joists in pier and beam construction. The subfloor is placed between the finished floor and the floor joists.

Sweating--the formation of moisture droplets on a cold surface when it comes in contact with warmer air.

Temperature design--the hottest or coldest temperature in an area. Used when sizing heating and air conditioning systems.

Temperature difference--the difference in temperature between the inside and the outside of a home.

Therm--a unit sometimes used in measuring natural gas for sale. One therm equals 100,000 Btu.

Threshold--a wood, metal, or vinyl device that fills the space at the bottom of a door.

U factor--a number indicating the amount of heat that will pass through a wall. The U factor is a composite of the K factors of the individual materials in the wall.

Vapor barrier--a material that prevents moisture from passing through or condensing on the walls of a structure.

Weather stripping--strips of material designed to be installed around doors and windows to stop the flow of air.

Weep hole--the hole in the bottom edge of a storm window to allow moisture to drain from the enclosed space.

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

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MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. The biggest single influence on heating energy consumption is:

   a. house design
   b. house location
   c. type of heating system
   d. the occupants

2. There is one national building code that applies everywhere.

   a. true b. false

3. All things being equal, a one-story, rectangular house will have less heat loss than a two-story house.

   a. true b. false

4. A single-pane window, with a typical U factor of 1.13, has a heat loss that is more than ______ times greater than a wall having a typical U factor of 0.10.

   a. 2
   b. 5
   c. 10
   d. 20

5. The addition of storm windows over single-pane windows can reduce heat loss by ______ percent:

   a. 5-10
   b. 10-20
   c. 20-30
   d. 40-60

6. The average amount of glazing found in most homes is ______ percent of the floor area.

   a. 15
   b. 25
   c. 35
   d. 50

7. The most important factor to consider when determining the amount of insulation to install is:

   a. the climate
   b. the type of roof
   c. the heat loss per square foot
   d. the occupants

8. When comparing K factors, the lower the K factor the better.

   a. true   b. false

9. The R factor differs from the K and U factors in that a large R factor is better than a small one.

   a. true   b. false

10. The smaller the R factor, the better the insulating material resists the flow of heat.

    a. true   b. false

11. An R value of _______ is usually recommended for ceiling insulation in the far northern states:

    a. 10
    b. 20
    c. 30
    d. 40

12. For most applications, there is little benefit to be gained by adding more than _______ inches of insulation:

    a. 2
    b. 4
    c. 6
    d. 8

13. The temperature difference between the inside and outside of the home is the main factor in determining how much insulation should be used.

    a. true   b. false

14. As much as _______ percent of the heat loss in a house is through the ceiling in the winter:

    a. 25
    b. 50
    c. 75
    d. 85

15. There is only one effective way to weatherstrip doors.

    a. true   b. false

16. In weatherizing windows, it is more desirable to install sheets of plastic _______ the window:

    a. inside   b. outside

17. The most durable caulking compounds are the:

    a. oil- or resin-based
    b. latex-, butyl-, or polyvinyl-based
    c. elastomeric

18. Which of the materials listed below has the most desirable K factor?

    a. corkboard
    b. brick
    c. stone
    d. sawdust

19. It is always best to install your own storm doors.

    a. true   b. false

20. Heat may be transferred by 4 different means.

    a. true   b. false

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

ANSWERS TO PRETEST

1. d. the occupants
2. b. false
3. a. true
4. c. 10
5. d. 40-60
6. a. 15
7. c. the heat loss per square foot
8. a. true
9. a. true
10. b. false
11. c. 30
12. b. 4
13. a. true
14. c. 75
15. b. false
16. a. inside
17. c. elastomeric
18. a. corkboard
19. b. false
20. a. true

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT I

CONSTRUCTION CONSIDERATION BEFORE BUILDING

UNIT OBJECTIVES

1. Recognize energy conservation potential in home building and remodeling.
2. Discuss and recognize the importance of building codes and the problems associated with them.
3. Discuss and recognize the three types of heat transfer.

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT I

CONSTRUCTION CONSIDERATION BEFORE BUILDING

LECTURE

INTRODUCTION

In many instances, people involved in writing energy conservation codes and standards fail to consider the overall design of the house with respect to energy-saving practices. They will specify that a certain amount of insulation be installed in the walls and ceiling of houses in certain areas of the country. This makes no sense, since it penalizes the builder who uses good design (proper orientation, small glazing area, etc.) by requiring that the same insulation be installed as in a poorly designed house.

Many design and construction features exist which the builder can incorporate into new homes in order to reduce energy consumption. Not all of these features will add to first cost. In fact, some of the most significant features in terms of Btu saved, such as less glass area, will reduce first cost. These various design features will be discussed in this module and the potential energy savings will be explained. The design features that will be discussed are those that apply to single-family housing, but not necessarily to other types of light residential construction.

A. HOME ENERGY CONSUMPTION

In order to build energy-conserving homes, it is important to understand what combination of design, operation, and construction result in the greatest energy use so that conservation efforts can be concentrated where they will do the

ACTIVITIES

The last unit at the end of this module is intended as a workbook for student use. It can be discussed throughout the module in relation to the lecture material.

The student should use Figure 1.2 to learn about the building codes in his/her city or town. Contact the local building contractors or building inspectors to gain details of building codes in your area.

most good. Generally, the greatest energy savings in residential buildings can be attained through reduction of air infiltration, primarily related to windows and doors, followed closely by the reduction of conductive heat transfer through the walls and windows.

In Report No. HUD-HAI-2 Residential Energy Consumption, Single-Family Housing, March 1973, prepared by Hittman Associates, Inc., Columbia, Maryland 21045, detailed theoretical quantitative thermal analyses were performed on typical single-family residences in the Baltimore/Washington area. This study revealed a distribution of heating and cooling loads by major components as shown in Figure 1.1.

FIGURE 1.1 BREAKDOWN OF HEATING AND COOLING LOADS FOR CHARACTERISTIC HOUSE USED IN HUD STUDY*

COMPONENTS	% OF HEATING LOAD	% OF COOLING LOAD
CEILING	3.7	2.3
FLOOR	2.2	2.4
TOTAL WINDOW	13.6	4.1
TOTAL DOOR	1.4	0.4
TOTAL WALL	23.9	14.2
INFILTRATION LOAD	55.2	41.5
INTERNAL LOAD	--	35.1
	100.0	100.0

As can be seen, the infiltration load was 55.2 percent and 41.5 percent for heating and cooling respectively. Also significant is the fact that the internal load, i.e., appliances, lights, and occupants, was 35 percent of the cooling requirements. Analysis of the internal load showed that 25 percent of the heat gain was from the occupants, 19 percent from the lights, and 56 percent from appliances.

Heating requirements measured in this study were interpreted in terms of primary energy requirements by use of a gas- fired furnance. Cooling requirements were interpreted in terms of primary energy requirements by use of an electrically-driven central air cooling unit. Heating and air conditioning will not be discussed in this module. For specific discussion on heating and cooling, refer to Module #10 of this series.

B. HOME ENERGY CONSERVATION POTENTIAL

From the data mentioned above, it can be seen that a great potential for energy conservation lies in the design and construction of a house, particularly with regard to reducing the infiltration load. Dozens of design and construction features can be incorporated into new homes to reduce energy consumption. However, there may be problems in doing so. First, there is a lack of cost versus energy-saving data on many of these features. Second, many worthwhile energy-saving design features in one part of the country may not be so in another part. It is likely, however, in view of the rapidly rising energy costs, that most of the items mentioned in this unit will be economically advantageous in the long run.

Metered tests on energy consumption for heating have shown that the amount of energy used for heating a house is not necessarily related to the design heat loss of the house. The biggest single influence on heating energy consumption is the occupants themselves. Identically built adjacent houses can easily have heating energy consumption variations of 50 percent due to occupant life style. Consumer operating procedures is, therefore, another important area of potential energy saving. Numerous operating procedures can, and should, be encouraged to reduce energy consumption. Substantial energy savings can be realized by educating the homeowner to more efficiently operate the dwelling. Before discussing building construction, it is important to understand the principles of heat transfer through conduction convection, radiation, and evaporation.

C. METHODS OF TRANSFERRING HEAT

Heat energy is moved or transferred from one place to another chiefly by three methods: conduction, convection, and radiation. All homes are heated or cooled using at least one of these methods. The reason it is important to know something about them is that they greatly affect the efficiency of heating and cooling equipment. When the transfer of heat becomes inefficient, it costs more to heat and cool a home.

1. Conduction simply means heat is transferred by direct contact. When a pot is placed on the burner of a stove, the heat energy is transferred from the burner to the pot. If the stove is electric, the pot rests directly on top of the heating coil. If the stove is gas, the flame touches the pot. In either case, the conduction requires a good contact between the source of the heat and the object to be heated. Dirt and soot between the source and object can destroy the efficiency of heat conduction in a furnace by acting as an insulator to slow down the transfer of heat. On the other hand, good insulation in a home can reduce the heat load and heat gain.

2. Convection simply refers to the heating or cooling of liquids and gases. When heating a gas such as air, the air molecules are free to move about and mix together. Warm air rises and cool air falls, but the air currents that are created in this way tend to churn and mix the air so that its temperature becomes nearly uniform. Some conduction heating does take place, but the mixing or convection process dominates. The cool air drawn into a gas furnace is heated by convection in the burner box. Similarly, a baseboard electric heater draws cool air in at the bottom, where it is heated by convection as it passes over the hot fins inside, and then

the entire room is heated by convection as the hot air rises and circulates throughout the room. Steam and hot-water furnaces also use the principle of convection heating. Air coolers use a more complex process involving Freon on the inside, but heating and cooling the air on the outside works by simple convection. The efficiency of convection heating and cooling is reduced by dust and dirt and by restrictions that slow the circulation of the air.

3. Radiation is the third method of heat transfer and it differs quite a bit from either conduction or convection. The best example of radiation is sunlight or solar heat. When one stands in the sun, the body receives warmth from the rays of heat energy from the sun. But only that part of the body exposed to the sun is actually warmed by radiation; the shaded part is not warmed at all. Radiation is also at work when one stands in front of a fireplace or any other very hot source of heat. Heat lamps and even ordinary light bulbs give off heat radiation. Anything that is hot enough will emit infrared (heat) radiation, though it doesn't have to be hot enough to glow or give off light. The important characteristic to remember is that radiation always travels in a straight line; it cannot go around corners. However, heat radiation can be reflected just as light can, so shiny and light-colored surfaces can be used to reduce the heating effect of radiation. Radiation heat can be effective in some applications, and it is the main principle behind the operation of electric and gas-fired space heaters.

4. Evaporation, another method of heat transfer, deserves mentioning, although it is readily a combination of conduction and convection. Evaporation is an important form of heat transfer that enters into most heating and cooling operations.

Both water and water vapor may feel just as warm to a person when they are at the same temperature, but the fact is that water vapor contains more heat energy. Thus, as water evaporates, the vapor draws heat energy out of the remaining water, making it cooler. Furnace humidifiers use heat energy in humidifying the air, but because the air feels warmer and much more comfortable, it is possible to turn the thermostat down a couple of degrees.

Evaporation works both ways, however, for in order to condense the water vapor from the air, the extra heat energy must be removed from the water vapor to turn it back into water. In fact, an air conditioner has to work almost as hard to reduce the humidity of the air by one percent as it does to reduce the temperature of the air by one degree. That is why it is so important in summer to use an exhaust fan to remove steam created by cooking and showers, rather than to make the cooler work extra hard in removing it. The exhaust fan is a much cheaper way to cope with water vapor.

D. BUILDING CODES

Another consideration before building is that of building codes. A building code is intended to set minimum construction standards to protect the health and safety of building occupants. Codes control such diverse things as property setback limits, areas of rooms and windows, sizes and spacing of structural members, and design requirements for stairways and exits. Separate codes are usually written to cover plumbing and electrical wiring. The more recent and progressive codes are written on a performance basis, which means that the desired ends, rather than the exact means of achieving them, are stated. An example would be a code requiring a floor construction capable of carrying a load of 40 pounds per square foot as opposed to one which

The student should use Figure 1.2 to learn about the building codes in his/her city or town. Contact the local building contractors or building inspectors to gain details of building codes in your area.

specifically lists the various materials and spacings of structural members that are acceptable. The first will allow new or different types of construction, while the latter is merely a rubber stamp for the status quo.

The ideal solution would be to have one national code which applies everywhere. The electrical industry has pretty well succeeded in getting the National Electrical Code adopted uniformly throughout the country. The National Plumbing Code is also widely used, but is by no means universal. Three different major attempts have been made to create a national code which covers building construction. Unfortunately, the results were just three more codes. Since writing a good code is an extremely expensive and complicated task, few smaller states or cities write their own. They merely adopt one of the so-called "national codes," with or without local modification. The three "national codes" are the National Building Code, the Southern Building Code, and Building Officials' Code of America, normally pronounced as one word, "BOCA." The latter code is the most progressive and, fortunately, the most widely adopted.

How do you tell which code, if any, you should follow? Normally, the local government unit--city, town, village, or county--administers whatever code is used. In many instances, even though there may be a state code, it is up to the local community to set up enforcement of the code through a building inspector. If the community doesn't have an inspector, there is no way to enforce the code. Even if there is no building inspector, it would still pay to follow the code as closely as possible to avoid possible trouble with banks and insurance companies.

Whether the code will be a help or a hindrance depends on where one resides. For example, California and Massachusetts have recently adopted state codes which were written in the "bigger is better" era. Both of these codes make life difficult for those who wish to build small houses or do construction themselves. Remember, though, that these states require the local community to enforce the code. Careful selection of a homesite may enable one to avoid quite a few hassles. On the other hand, many new and sensible codes are "in the works" because of the energy crisis. The federal government is considering minimum insulation standards on a national basis. How these standards are to be enforced is still unknown. In any case, it will pay to insulate as heavily as possible, so don't be afraid of any such restrictions.

For those would-be builders who do have to face the reality of codes, there is some advice on how to deal with them. (1) First, obtain a copy of the code which has been adopted locally. (2) Find out who is responsible for the enforcement of the code. Most towns have one or more building inspectors who issue building permits and then follow up with field inspections to see that the construction conforms to the code. (3) After obtaining the code, read it thoroughly. It will pay to get a copy of the code before committing oneself to the purchase of a piece of property. Refer carefully to the checklist at Figure 1.2 to see if there are any provisions which can't be met. It is possible for someone to sell you a piece of property on which you can't legally build! (4) Also, study carefully the beginning sections of the code book concerning jurisdiction, enforcement, and appeals. After doing all of these, consider building a home.

FIGURE 1.2
BUILDING CODE CHECKLIST

ITEM	CODE REQUIREMENTS		CAN YOU MEET IT?	
	YES	NO	YES	NO
1. Minimum area of lot (lot size)				
2. Number of families permitted				
3. Minimum or maximum house area				
4. Building height and set-back restrictions				
5. Foundation type (Is masonry required?)				
6. Is post and beam framing permitted?				
7. Is grade stamped lumber required for framing (i.e., new and kiln dried)?				
8. Minimum room sizes				
9. Minimum door sizes and number of exists				
10. Window sizes and ventilation requirements				
11. Forced ventilation for kitchen and baths				
12. Fire retardant enclosure for exitways				
13. Fire alarm system				
14. Riser and tread sizes for stairs				
15. Minimum insulation requirements				
16. Chimney clearances (Is prefab allowed?)				
17. Can owner finish a shell by contractor?				
18. Can attic or some rooms be left unfinished?				

The above list is by no means comprehensive. It is intended to call to your attention the most likely code restrictions that might adversely affect your construction of a house or remodeling or an existing building.

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT II

BUILDING SITE AND DESIGN

UNIT OBJECTIVES

1. Recognize the significance in building orientation.
2. Discuss the significance of designing houses to utilize wall and glass area to control heat loss and heat gain.
3. Discuss the relationship between floor area and percentage of glazed area.
4. Compute annual estimated heating and cooling cost savings for installing energy conservation measures, such as storm doors and windows.
5. Explain the meanings of: K factor, U factor, and R factor, and to compute each for certain building materials.
6. Distinguish between various types of insulation material.
7. Recognize the significance in heat loss in wall, ceiling, and glazed areas, and to insulate for better efficiency.
8. Discuss the advantages of shading devices for saving energy.
9. Discuss the effects of building mass on energy conservation.

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT II

BUILDING SITE AND DESIGN

LECTURE

A. ORIENTATION

When a builder decides to investigate the possibility of building in a particular location, there are several things which must be taken into account in considering the site. Among these are (1) accessibility to roads and utilities, (2) proximity to schools, churches, shopping centers, (3) topographic features, (4) drainage patterns and (5) other factors which will influence development of the site. Having decided the development is feasible and that a market exists for the dwellings that can be built on the land, the buyer should now proceed one step further and consider how best to design and site the dwellings to enhance energy conservation.

1. The first thing that the builder should consider is the type of house to be built. Should the builder build a single-story or two-story dwelling or a combination? What shape should it be? At first glance it would appear that a two-story dwelling would have less heat loss than a one-story dwelling of the same square feet of floor space. This can be illustrated by taking the dimensions of a house and computing the total area of the exterior walls and ceiling where insulation is required, and then comparing it to the same house converted to a one-story dwelling.

ACTIVITIES

Refer to page 2 of the workbook to follow along with this topic of lecture.

a. Two-story
36' wide; 24' deep; 15'9" high
Walls
36' x 15.75' x 2 = 1134 ft.^{2}
24' x 15.75' x 2 = 756 ft.

1890 ft.^{2}

Ceiling
36' x 24' = 864 ft.^{2}

2754 ft.^{2}

b. One-story Rectangular--Short
36' wide; 48' deep; 7' 6 1/2" high
Walls
36' x 7.54' x 2 = 543 ft.^{2}
48' x 7.54' x 2 = 724 ft.

1267 ft.^{2}

Celing
36' x 48' = 1728 ft.^{2}

Total 2995 ft.^{2}

c. One-story Rectangular--Long
72' wide; 24' deep; 7' 6 1/2" high
Walls
72' x 7.54' x 2 = 1086 ft.^{2}

24' x 7.54' x 2 = 362 ft.^{2}

1448 ft.^{2}

Ceiling
72' x 24' = 1728 ft.^{2}

Total 3176 ft.^{2}

$$\text{Est. Annual Heating Cost} = \frac{\text{Heat Loss x HI x 24}}{\Delta t \text{ x } 100{,}000}$$

= \$/year

$$\text{Est. Annual Cooling Cost} = \frac{\text{Heat Gain x CI}}{100{,}000}$$

= \$/year

$$\frac{\text{(K factor) x (width) x (length) x (temperature difference)}}{\text{(increase in thickness)}}$$

$$= \frac{0.27 \text{ x } 12 \text{ x } 8 \text{ x } 10}{} = \frac{129.6 \text{ Btu}}{\text{per hour}}$$

$$U = \frac{1}{\frac{\text{thickness of A}}{\text{K factor of A}} + \frac{\text{thickness of B}}{\text{K factor of B}} + \frac{\text{thickness of C}}{\text{K factor of C}}}$$

The total area of walls and ceiling in the two-story dwelling is less than one-story dwellings of same floor area. This would give the impression that there is less heat loss in the two-story house. If we examine the figures more closely we will note that the total wall area of (a) is 1800 ft^2, that of (b) is 1267 ft^2 and (c's) wall area is 1448 ft^2. This data is significant for several reasons. First, we must consider the insulating capability of the structure. The typical maximum full thickness insulation used in 2' X 4' walls is R-11 which limits the heat loss reduction per square foot to a fixed amount. Much thicker insulation can be used in ceilings, which means that ceilings have a potential for greater heat loss reduction. Thus, the one-story houses with the larger ceiling area, 1728 sq. ft., to which the greater amounts of insulation can be applied, can have less heat loss (at lower insulation costs) than a two-story house which has the greater wall area. Of the two, a one-story, rectangular house with the least wall area can be expected to have less heat loss, all things being equal. This alone tends to offset, to some degree, the fact that the two-story dwelling has less total area of walls and ceilings.

2. The second and more important factor we must look at is the amount of glazed area in the structure, since the greatest percentage of heat loss and gain is usually through infiltration which typically occurs around window and door openings. Most codes require a minimum glazed area of 10 percent of the floor area.

(3) During the planning phase, attention must be given to the orientation of the house as well as to its design. In order to achieve proper building orientation, many factors must be taken into account. The topography, noise levels, scenic views, concern for privacy, and the climatic factors of wind and solar radiation are all important and have a direct bearing on the livability of housing.

(4) The most complicated and often ignored factor affecting orientation is solar radiation. There are many variables to take into account. The wind, seasonal changes, and regional climatic differences in the United States make this a difficult subject to talk about. For example, in northern latitudes where the air is generaly cool, there is a need to orient the building toward the sun, but in southern regions the axis of the building should be turned to avoid direct solar radiation and oriented toward cooling breezes instead. In the more temperate zones where winter heating and summer cooling are both important, a dual role is required of the structure and orientation often becomes a more difficult and critical factor to consider.

Generally, for best living conditions (warmth in winter, coolness in summer), principal facades of buildings should face south. In cool regions the optimum orientation (i.e., the direction the long side of the house should face) lies 12°E of south, in hot, humid regions, 50°E of south is desirable; in hot, arid regions direct southern exposure to 35°E of south is acceptable; and in temperate regions, 17 1/2°E of south achieves a balanced heat distribution. The most troublesome orientation is toward the west. Walls facing into the direct summer afternoon sun absorb radiant heat at a time when the house may have already become overheated due to radiant heat from the sun and warm air outside. During the winter, the prevailing cold winter winds impinge on west walls in many locations. The chart in Figure 2.1 offers suggested sun orientation for residential rooms.

FIGURE 2.1

SUGGESTED SUN ORIENTATION

	N	NE	E	SE	S	SW	W	NW
BEDROOMS	X	X	X	X	X	X		
LIVING				X	X	X	X	
DINING			X	X	X	X	X	
KITCHEN			X	X	X	X		
LIBRARY	X	X						X
LAUNDRY	X	X						X
PLAY				X	X	X	X	
DRYING YD.				X	X	X	X	
BATHROOMS	X	X	X	X	X	X	X	X
UTILITY	X	X						X
GARAGE	X	X	X	X	X	X	X	X
WORKSHOP	X	X						X
TERRACES			X	X	X	X	X	
SUN PORCH				X	X	X	X	

B. GLAZING

The amount of glazed area is important as far as energy conservation is concerned. In fact, windows and doors, with their associated air infiltration loads, are components as important to heating and cooling requirements as is insulation of wall and ceiling areas.

Most codes require a minimum glazed area of 10 percent of the floor area. The window area of most dwellings is normally about 15 percent of the floor area. A single-pane window, with a typical U factor of 1.13,

Turn to pages 7 and 8 in the workbook to follow the lecture with laboratory material.

has a heat loss that is more than 10 times greater than a residential wall or ceiling having a typical U factor of 0.10. Double-pane windows (also called insulated glass or "thermopane") have a U factor that is about 0.50, which is less than half as much as a single-pane window.

Adding storm windows over the single-pane windows of your home can also reduce heat loss by 40-60 percent. Adding storm doors to existing door frames can have a similar effect. Window awnings may also be used to advantage in sunny exposures to reduce radiated heat passing through the window by about 15 percent.

When reducing window areas, it is recommended the reduction be done by raising the sill height. By doing so, the upper portion of the window, which provides better natural illumination, remains in place. This also helps reduce heat gain in the summer because the upper portion of the window is more easily shaded by overhang. Using light color finish for walls, ceilings, and floors will further enhance the level of natural light.

The decision about installing storm windows and storm doors is one largely based on economic feasibility. Will the amount of energy savings be worth the extra cost? This can be determined by calculating the annual estimated heating and cooling cost savings.

$$\text{Est. Annual Heating Cost} = \frac{\text{Heat Loss} \times \text{HI} \times 24}{\Delta t \times 100{,}000}$$

$$= \$/\text{year}$$

$$\text{Est. Annual Cooling Cost} = \frac{\text{Heat Gain} \times \text{CI}}{100{,}000}$$

$$= \$/\text{year}$$

HI=Heating Index factor, which combines heating degree days, cost of fuel and average efficiency of heating system.

CI=Cooling Index, which combines operating hours per season, cost of fuel or electricity for cooling and system efficiency.

Δt=temperature difference between 70°F inside and winter design temperature.

In addition to relating to heat loss in the winter, the design of glazing can also have a considerable impact on the cooling load of the house in the summer. The area, location, and shading of windows and the use of double glazing or storm sash are important energy conservation factors for cooling.

C. INSULATION

There is no simple answer to the question of how much insulation should be used. The optimum amount of insulation depends on a number of factors which vary from city to city, such as severity of heating or cooling season, first costs of installing insulation, fuel and energy rates, etc. However, the most important factor to consider when determining the amount of insulation to install is the heat loss per square foot that is to be achieved.

Another important factor to consider when deciding how much insulation to use is the first cost involved compared to the amount of savings that will result in operating costs over the life of the house.

Workmanship is important also. The manner in which insulation is installed can have as great an effect on heat loss or gain as the insulation itself.

Turn to pages 10 through 15 of the workbook for laboratory material.

In order to understand insulation, one must be familiar with the terminology of heat transfer. The conducting or insulating properties of different materials are rated using three factors. Actually, all three factors give essentially the same information, but they are used in slightly different ways. The proper understanding and use of these factors can help in selecting everything from basic building materials to complete walls, ceiling and floors. The heat transfer factors are represented by the letters K, U, and R. At least one of these letters will appear in a variety of tables and charts that list the insulating properties of either basic building materials or standard structures already containing various types of insulation.

For convenience in comparing and working with these factors, all are based on a one-square-foot section of the material and on a one-degree temperature difference between surfaces. The thickness of the material may vary, but it is always listed in the table with the heat transfer value.

1. The K Factor

The K factor is a conduction factor that tells you how much heat energy will pass through a piece of insulating material. The K factor is given in Btu per hour for one square foot of surface area, and a temperature difference between surfaces of one degree. All heating and cooling loads, furnaces, and air conditioners are rated in Btu per hour, so the K factor gives you information that is immediately usable.

Figure 2.2 gives some K factors for common materials. For example, the K factor for a one-inch-thick piece of cork board is 0.27. This means that a piece of cork measuring one foot by one foot will allow 0.27 BTU per hour to pass through if the temperature difference is one degree. Doubling either the temperature difference or the surface area will double the heat conduction, but doubling the thickness of the material will cut the heat conduction in half. In other words, K factors for any thickness material covering any size area and for any temperature difference can be used. Just multiply the K factor by the actual temperature difference and by the surface

FIGURE 2.2

K FACTORS FOR COMMON BUILDING MATERIALS

MATERIAL	THICKNESS	K FACTOR
CORK BOARD	1"	0.27
FIBERGLASS	1"	0.27
GLASS FOAM	1"	0.40
POLYSTYRENE FOAM	1"	0.15
ROCK WOOL	1"	0.29
FIR	1"	0.67
PINE, SOFT	1"	0.86
PARTICLE BOARD	1"	0.50
SAWDUST	1"	0.41
BRICK, FACE	1"	10.00
BRICK, COMMON	1"	5.00
GYPSUM WALL BOARD	1"	0.70
STONE	8"	0.70
STONE	12"	0.50
CINDER BLOCK	8"	0.50
	12"	0.35
CONCRETE, BLOCK	8"	0.55
	12"	0.45
CONCRETE, POURED	8"	0.70
	12"	0.50

area, and divide the K factor by the proportionate increase in thickness. For example, by tiling an 8 ft. x 12 ft. wall with corkboard that is 2 in. thick, and the temperature difference is 10 degrees, the heat conduction would be:

$$\frac{(\text{K factor}) \times (\text{width}) \times (\text{length}) \times (\text{temperature difference})}{(\text{increase in thickness})}$$

$$= \frac{0.27 \times 12 \times 8 \times 10}{2} = 129.6 \text{ BTU per hour}$$

Be careful when using any of these heat transfer factors that careful note is made of the thickness of the material given in the table. Often the thickness is given for standard product sizes, as for concrete blocks. But in other cases the thickness is for just one inch. For example, if six inches of fiberglass with the K factor of one inch was used, one would divide by 6 since six times as much insulation was used. But if six inches of poured concrete was used, when the K factor given is for eight inches, then it would be necessary to divide by 6/8, or 3/4, since only 3/4 as much material was used.

All building materials--fir, pine, brick, concrete, foam insulation, etc.--have their own K factors. Materials that conduct heat more rapidly have higher K factors than materials that insulate well. So when comparing K factors, the lower the K factor, the better.

2. The U Factor

The U factor is a universal factor because it applies to wall construction rather than to specific materials. If the wall construction is known, then the various K factors for each material could be used to find out what the heat conduction would be through the wall. But this approach would be rather tedious, and it might not be very accurate either. If available, the U factor is the one to use because it often takes into account the effect of wind speed and surface finishes on each side of the wall. For our purposes, we will ignore such details as finishes, air films, and wind speeds, since these have only a minor effect on the final heat conduction value.

Like the K factor, the U factor is also expressed in Btu per hour for a one-square-foot area of wall and a one-degree temperature difference. Knowing the U factor of a wall allows one to figure what amount of heat is escaping. Then the U factors of different wall constructions can be compared to determine what type of construction has the lowest heat conduction and, therefore, the best insulation properties. Knowing the U factor also helps in quickly determining the heat load of a home, since the same Btu are used in calculating heat loads.

Heating contractors and utility companies use charts and tables when estimating heat loads that are based on typical constructions and home designs in their location. These charts already include the winter design temperatures in your area, so it is only necessary to know the general size and home style (ranch, bungalow, etc.) in order to estimate heating requirements to a fair degree of accuracy. But if such detailed charts are not readily available, or if a home differs greatly from the typical homes listed, then the heat load can be determined by multiplying the U factor of each wall by the area of the wall and by the temperature difference.

To find the U factor of a wall from the K factors of each material in the wall, use the following formula:

$$U = \frac{1}{\frac{\text{thickness of A}}{\text{K factor of A}} + \frac{\text{thickness of B}}{\text{K factor of B}} + \frac{\text{thickness of C}}{\text{K factor of C}}}$$

where A, B, and C are the materials in the wall.

It is easy to see that this would be a fairly cumbersome method of figuring the heat loss through a wall. For this reason, the charts and tables for complete walls are much more desirable to work with. Such charts can show at a glance what effect added insulation can have on a home, whether it is already built or still in blueprint form. It will also be possible to see what effects different sidings and insulation materials have, as when adding aluminum siding over an existing lap or shingle siding. (Aluminum siding, by the way, also comes with insulation on the underside.) The U and K factors can be of great help when designing a new home, permitting selection of materials that can prevent a lot of heat loss.

3. The R Factor

The R factor is a resistance factor that tells how much a given material resists the flow of heat through it. The R factors given in Figure 2.3 show typical values for common building materials.

FIGURE 2.3

Resistance Values of Structural and Finish Materials, Insulations, Air Spaces, and Surface Films*

Wood bevel siding, 1/2 x 8, lapped	R-0.81
Wood siding shingles, 16", 7½" exposure	R-0.87
Asbestos-cement shingles	R-0.03
Stucco, per inch	R-0.20
Building paper	R-0.06
1/2" nail-base insul. board sheathing	R-1.14
1/2" insul. board sheathing, regular density	R-1.32
25/32" insul. board sheathing, regular density	R-2.04
1/4" plywood	R-0.31
3/8" plywood	R-0.47
1/2" plywood	R-0.62
5/8" plywood	R-0.78
1/4" hardboard	R-0.18
Softwood, per inch	R-1.25
Softwood board, 3/4" thick	R-0.94
Concrete blocks, three oval cores	
Cinder aggregate, 4" thick	R-1.11
Cinder aggregate, 12" thick	R-1.89
Cinder aggregate, 8" thick	R-1.72
Sand and gravel aggregate, 8" thick	R-1.11
Lightweight aggregate (expanded clay, shale, slag, pumice, etc.), 8" thick	R-2.00
Concrete blocks, two rectangular cores	
Sand and gravel aggregate, 8" thick	R-1.04
Lightweight aggregate, 8" thick	R-2.18
Common brick, per inch	R-0.20
Face brick, per inch	R-0.11
Sand-and-gravel concrete, per inch	R-0.08
Sand-and-gravel concrete, 8 inches thick	R-0.64
1/2" gypsumboard	R-0.45
5/8" gypsumboard	R-0.56
1/2" lightweight-aggregate gypsum plaster	R-0.32
25/32" hardwood finish flooring	R-0.68
Asphalt, linoleum, vinyl, or rubber floor tile	R-0.05
Carpet and fibrous pad	R-2.08
Carpet and foam rubber pad	R-1.23
Asphalt roof shingles	R-0.44
Wood roof shingles	R-0.94
3/8" built-up roof	R-0.33
Glass	
Single glass (winter)	U = 1.13
Single glass (summer)	U = 1.06
Insulating glass (double)	
1/4" air space (winter)	U = 0.65
1/4" air space (summer)	U = 0.61
1/2" air space (winter)	U = 0.58
1/2" air space (summer)	U = 0.56
Storm windows	
1" to 4" air space (winter)	U = 0.56
1" to 4" air space (summer)	U = 0.54
Insulation	
2" – 2½" thick	R-7.00
3" – 4" thick	R-11.00
5" – 7" thick	R-19.00

Air Spaces (3/4")	
Heat flow UP	
Non-reflective	R-0.87
Reflective, one surface	R-2.23
Heat flow DOWN	
Non-reflective	R-1.02
Reflective, one surface	R-3.55
Heat flow HORIZONTAL	
Non-reflective (also same for 4" thickness)	R-1.01
Reflective, one surface	R-3.48
Note: The addition of a second reflective surface facing the first reflective surface increases thermal resistance values of an air space only 4 to 7 per cent.	
Surface Air Films	
INSIDE (still air)	
Heat flow UP (through horizontal surface)	
Non-reflective	R-0.61
Reflective	R-1.32
Heat flow DOWN (through horizontal surface)	
Non-reflective	R-0.92
Reflective	R-4.55
Heat flow HORIZONTAL (through vertical surface)	
Non-reflective	R-0.68
OUTSIDE	
Heat flow any direction, surface any position	
15 mph wind (winter)	R-0.17
7.5 mph wind (summer)	R-0.25

Example calculations
(to determine the U value of an exterior wall)

Wall Construction	Uninsulated Wall Resistance	Insulated Wall Resistance
Outside surface (film), 15 mph wind	0.17	0.17
Wood bevel siding, lapped	0.81	0.81
½" ins. bd. sheathing, reg. density	1.32	1.32
3½" air space	1.01	
R-11 insulation		11.00
½" gypsumboard	0.45	0.45
Inside surface (film)	0.68	0.68
Totals	4.44	14.43

For uninsulated wall, $U = \frac{1}{R} = \frac{1}{4.44} = U = 0.22$

Therefore, heat loss for the above uninsulated wall section at a +10° F. outside design temperature is equal to 0.22 x 60 (or 70-10) equals 13.2 Btuh per sq. ft. of wall section.

For insulated wall, $U = \frac{1}{R} = \frac{1}{14.43} = U = 0.07$

Therefore, heat loss for the above insulated wall section at a + 10° F. outside design temperature is equal to 0.07 x 60 (or 70-10) equals 4.2 Btuh per sq. ft. of wall section.

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* Additional resistance values can be obtained from ASHRAE Handbook of Fundamentals published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers.

The R factor differs from the K and U factors in that a large R factor is better than a small one. In other words, the larger the R factor, the better the material resists the flow of heat. Most insulation materials have R factors printed on them. Look closely at a roll of fiberglass insulation to find an R number printed on it. For example, a roll of four-inch-thick fiberglass might have the number R-11 printed on it, which indicates that its R factor is 11. Building specifications will often list an R number for the insulation and leave it up to the contractor to meet the requirements with the most economical materials available. For example, in the far northern states, the use of R-30 ceiling insulation and R-19 insulation in floors is recommended.

The R factor is just the reciprocal of the U factor; that is, R=1/U and U=1/R. The wall in the previous example had a U factor of 0.65, which is equivalent to an R factor of 1/0.65, or 1.54. So the R factor of the wall was 1.54. Reversing the calculations, if the R factor of the wall is known, the U factor, can be found, since U=1/R.

The R factor is the principle factor used to rate the effectiveness of insulation, and most materials have an R factor printed on them. But most building materials such as wood, brick, siding, etc. are usually rated in K and U factors, although it is simple to convert them to R factors. Heating contractors and most fuel companies normally use U factors to figure the heat load of a house, while electric power companies seem to favor using R factors (probably because of the similarity to electrical resistance).

The most important use of the R factor is as an aid to the homeowner in determining the resistance of the various types of insulation. With the R values, the insulating qualities and costs can be compared to determine which type is best for a particular use.

4. Types of Insulation

There are several features to compare when looking at the insulators that are commercially available: cost, resistance factor per inch of thickness, fire rating, and durability.

Before we examine the various qualities that different insulators have, let's look at the forms of insulation that are available:

a. Forms

(1) Blankets, which come in rolls, usually from 16 to 24 inches wide, and are unwound and cut to fit in place between wall studs or ceiling and floor joists.

(2) Batts, similar in widths to blankets, but precut to specified lengths.

(3) Boards, rigid, precut to standard sizes and usually applied with a mastic as perimeter insulation around the foundation or over existing walls in renovation work.

(4) Loose-Fill, a loose granular material which is sold in bags, and can be poured into place between joists or behind walls where other types are difficulty to install.

(5) Blown insulation, a spray-foam material which is blown under pressure behind walls and between joints in ceilings and floors, by professionals.

Now, let's look at the qualities of the various commercial insulators:

b. Qualities

(1) Fiberglass, probably the most common of all insulators today, is available in rolls or batts. The resistance of fiberglass is about 3.5 per inch of thickness, is fire and vermin proof, moderate in cost, and easy to install. However,

over some years it will tend to mat down or settle on itself. The result is that the material is compressed a bit and loses some of its insulation value.

(2) Mineral Wool, a material similar to fiberglass, except that the material is made from melted rock instead of glass. The resistance value is a bit less than fiberglass--about 3 per inch--and the problems with matting are even worse.

(3) Insulating Sheathing, a material made from wood fibers which is usually applied on exterior walls as a backing for siding. It comes in various thicknesses, usually between 1/2 and 1 inch. The resistance is about 2 per inch of thickness; and though it's water repellent, extended exposure to moisture will cause damage through mildew and rot.

(4) Plastic Insulation. The most common type of plastic insulation is polystyrene, which comes either as a blue "closed-cell" foam board or as white granule boards, made of granules that have been heated and pressure treated so they adhere together. The resistance of these materials is about 5.5 for the blue closed-cell type and 4 for the white granule type. Polyurethane, on the other hand, comes as closed-cell foam boards or can be professionally blown into place inside walls, ceilings, or floors as a foam. In either case, its resistance value is about 6.5 per inch. Polystyrene and polyurethane tend to be expensive. Moreover, while both are good insulators and do not attract moisture or vermin, there are extreme fire hazards involved. Both will burn very rapidly and give off toxic gases, particularly when placed in a vertical position.

These materials should therefore never be installed where they will be exposed. The best applications are for perimeter insulation on the outside of foundation walls.

(5) Loose-Granule Mineral-Based Insulators, usually vermiculite and perlite, available as loosefill insulation at moderate costs. The resistance is about 2.5 per inch. These materials are fire-proof and will not deteriorate from moisture, rot, or insect problems. However, settling out can be a problem, particularly when placed in a vertical position between wall studs.

(6) Cellulose Fiber, a material often made from recycled paper that has been chemically treated to resist fire, rot, and vermin. In addition, this kind of insulation has good sound-deadening properties. It comes as a loose-fill insulation, though this variety has the settling out problems of the fiberglass, mineral wool, or loose-granule mineral-based insulators.

D. WALLS

Adding insulation to a wall will increase its R value or decrease its U value. In either case, the amount of heat escaping through the wall will be reduced. Adding one inch of insulation to an uninsulated wall will reduce the heat loss through the wall by 40-50 percent. Adding two inches of insulation will reduce the heat loss by 60-65 percent. Adding three inches will cut heat loss by 70-75 percent, and adding four inches will cut heat loss by 75-80%. All of these quoted percentages depend on the particular type of insulation used and on the construction of the wall before insulation is installed, but they represent typical figures.

It now becomes evident that adding more and more insulation has less and less effect on the percentage decrease in heat loss through the walls. For most applications, there is little benefit to be gained by adding more than four inches, since the added cost generally outweighs the benefits received in fuel savings. The best approach is to use better insulation rather than thicker insulation.

The temperature difference between the inside and outside of the home is the main factor in determining how much insulation should be used in the walls, ceilings, and floors. In the northern part of the U.S., where cold winters are the rule, more money would be spent in obtaining more and better insulation than in the south. In some regions of the country, the cost of fuel is especially high, and this too dictates the use of more insulation. Aside from the heating aspect, there is also the cooling side, which would also benefit from added insulation. So, in the southern states, insulation can reduce the cost of cooling more than it would reduce the cost of heating.

The addition of insulation to the walls, ceilings, and floors of a home reduces heat transfer--convection, conduction, and radiation. Air is actually a very poor conductor of heat, even though it is able to transfer large amounts of heat energy by convection. The trick is to prevent the air from moving or circulating and this is the way most foam, spun, or batting insulation materials work. Some insulation, such as plastic foam and closed-cell insulation, actually creates dead air pockets by holding the air in sealed bubbles. Other insulation, such as batting and spun fibers, merely prevents the air from circulating freely. In either case, the motion of the air is drastically reduced and only a small amount of heat is transferred by conduction through the air.

Good insulation has a high R factor and a high resistance to the conduction of heat through the wall. Even though convection may be a significant factor of heat transfer within the wall cavity, the insulation properties of the wall itself are treated as a conduction effect. Therefore, the addition of insulation with the wall acts to lower the conduction of heat through the wall. The more insulation that is added to the wall, the higher the R value and the resistance to heat flow.

Even some of the best insulating materials can become rather poor insulators if allowed to get wet. The problem with moist air is that it can condense and saturate some insulations, permitting the water, which has a very high heat conductivity, to transfer heat energy through the wall. Even worse, the presence of water or high amounts of moist air can rot and warp wooden beams and paneling. In particularly moist locations, such as basement or other masonry walls, the best vapor barrier is obtained by using large sheets of plastic installed directly against the masonry wall. Large rolls of heavy gauge plastic are available from most building material suppliers for just this purpose, and the rolls are wide enough to extend from floor to ceiling and from wall to wall. Since concrete and cement-block walls are fairly poor insulators, it is a good idea to use at least some insulation behind the paneling in basements.

E. CEILINGS

Insulating the ceiling of a house is extremely important. As much as 75 percent of the heat lost in a house is through the ceiling in the winter, so obviously it is important that this area be well insulated. Insulation in the ceiling will hold in the heat, which has a tendency to rise and escape through the ceiling into the attic space. In the summer, the heat flow reverses and extremely hot temperatures in the attic warm the rooms in the living area below.

For most applications, 6-10 inches of insulation in the ceiling is needed to prevent excessive heat gain or loss through the ceiling. Again, this will depend on the area, winter and summer design temperatures, and other factors. Contact a local builder or insulation company to get recommendations. More than 10 inches of insulation (R-30) usually costs more than the extra insulation is worth, but this varies. Twelve inches of insulation (R-38) is justified in some northern states where fuel costs are especially high. There are several different ways that the ceiling can be insulated, including blown-in fiberglass batting insulation, or a combination of insulation types.

There are other ways to reduce the energy loss through the ceiling besides insulation, although this is the most important. One way to reduce heat gain in the summer is to lower the temperature of the attic above the living area of the house. When the attic is cooler, less heat will be transferred into the rooms below, and the air conditioner will have less of a load. The temperatures in attics can often exceed 125°F, and this adds a considerable amount of heat to the living space.

The attic temperature can be lowered by installing an automatic fan and vents. Just installing vents at each end of the attic will often allow enough air circulation to lower the temperature of the attic quite a bit, and forcing the ventilation with a fan can lower the temperature even more. A section discussing attic fans and giving installation tips appears in a later chapter.

The color of the roof has an effect on the amount of heat gain in the house. An important thing to remember here is that heat gain is undesirable in the summer, but it is desirable in the winter. This presents somewhat of a dilemma for the homeowner. While a dark-colored roof will absorb sunlight and add some desirable heat to the attic in the winter, this same dark roof will add heat to the attic in the summer when it is undesirable. A light-colored roof will help reflect the sun's rays and leave the attic somewhat cooler than a dark roof in the summer. From the standpoint of energy conservation, a light-colored roof is recommended because most homes stand to benefit more in summer than in winter. This is purely an energy-saving suggestion, however, since design or style will probably have more to do with the color and type of roof selected for a home than matters of energy conservation.

F. SHADING DEVICES

Sun control through shading devices is an important factor in considering heat gain and there are many ways to shade a structure. One of the most effective methods is the use of deciduous trees planted adjacent to a south window wall. The foliage screens out the summer sun and the bare branch structure allows the sun heat to reach the house during the winter season.

The homebuilder does not always have the luxury of a heavily wooded site and must utilize architectural methods in order to provide adequate shading. The most common method is roof overhang. A properly designed overhang on the south wall will protect the wall from summer sun and expose the wall to the winter sun.

The sun's arc is low in the winter and high in the summer. The south wall of the house should therefore have an overhang projection which shades the wall from the high summer sun but permits the sun to warm the south wall during the winter months.

There are other examples of shading and screening devices which can also offer aesthetic value as well as energy conservation value. Such methods include the wooden trellis, louvered overhangs, canvas awnings and panels, horizontal and vertical louvered panels, adjustable shutters for windows and doors, and masonry grills.

G. EFFECTS OF BUILDING MASS ON ENERGY CONSUMPTION

All other things being equal including color and "U" value, buildings employing heavy-weight walls and roof exhibit beneficial characteristics with regard to energy, particularly for cooling.

When the sun shines through a window, heat gain to the space is almost always instantaneous. Similarly, when the sun shines on light-weight walls, the energy that it imparts to the wall is transmitted into the room in a short period of time. Obviously, the cooling equipment must have the capacity to remove this heat at the time that it enters the room, or shortly thereafter.

When heavy-weight construction is used, sun's energy requires more time to go through the heavy weight material. This time can range from a few hours up to as much as half a day. The peak heat gain into the space is therefore delayed by several hours and generally tends to be smoothed out over several hours, so that both the capacity of the cooling equipment and the amount of energy required can be reduced. The energy reduction results because: (1) air conditioning equipment operates more efficiently at night because the outside temperatures are usually lower, and (2) as the outside temperature drops at night, some of the heat that has been stored in the wall can reverse its flow and therefore never enter the space at all.

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT III

WEATHERIZATION

UNIT OBJECTIVES

1. Discuss weatherization practices available to the homeowner for more efficient doors.
2. Discuss weatherization practices available to the homeowner for more efficient windows.
3. Identify various types of caulking compounds and their life expectancy.
4. Discuss the advantages of caulking for saving energy.
5. Identify and discuss conservation practices in the home during the heating season.
6. Identify and discuss conservation practices in the home during the cooling season.

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT III

WEATHERIZATION

LECTURE	ACTIVITIES
One of the most important ways that energy can be conserved in the home is by weatherization. Through weatherization, more heat is kept inside the house during the winter months and outside during the summer months. Some of the most important factors that should be considered in the process of weatherization.	The information gathered in Unit IV should be discussed with this unit to learn of weatherization measures one can take to increase energy efficiency in the home.

A. Doors

Doors should be located away from prevailing winds in cold climates and facing into the wind in warm climates.

1. Weatherstripping

Even the most inexperienced person can weatherstrip doors with little difficulty. There are several different types of weatherstripping that may be used, including adhesive-backed foam, rolled vinyl with aluminum channel backing, foam rubber with wood backing, and spring metal.

While the adhesive-backed foam is easy to install, and almost invisible when installed properly, it is not very durable and is more effective on doors than on windows. The only tools needed for its installation are a knife or shears and a tape measure. To install, simply measure the amount needed, stick the foam to the inside face of the jamb, and press in place.

Rolled vinyl with aluminum channel backing is visible when installed, but is easy to install and is very durable. To install, measure and cut the amount of stripping necessary, and nail the strip snugly against the door casing.

Foam rubber with wood backing may be used in stripping doors, but it is not very durable and is visible when installed. To install, measure the amount needed, cut and nail the strip against the door casing, spacing the nails about eight inches apart.

Another material mentioned that might be used for weatherstripping doors is spring metal. In addition being easy to install and invisible when installed properly, it is also very durable. Measure the amount needed, cut with tin snips to the proper length, and nail in place. For a better seal, lift the outer edge of the strip with a screwdriver after tacking.

Door shoes are good for stripping the bottoms of doors, and are useful with wooden thresholds that are not worn. Door shoes are very durable, but very difficult to install. The door must be removed and the required amount trimmed off the bottom edge. Cut the shoe to the door width. Install by sliding the vinyl out and fastening the shoe to the bottom of the door with screws. (Tools required for this job are a screwdriver, hack saw, plane, and tape measure.)

A vinyl bulb threshold is another possibility for weatherproofing the bottoms of doors. This type of threshold is especially useful when there is no threshold, or when the wooden one is wornout. It is difficult to install and the vinyl will wear out, but replacements are available. To install this type of threshold, you will need a screwdriver, hack saw, plane and a tape measure. First, remove the door and trim the required amount off the bottom. The bottom should have about 1/8" bevel to seal against the vinyl. Make certain that the bevel is cut in the right direction for opening. The vinyl bulb should seal around the bottom of the door when the door closed.

Another possibility for sealing the air leak under your door is the interlocking threshold. However, it is extremely difficult to install and should be installed by a skilled carpenter. It does form a very good weather seal.

Interlocking metal channels may also be used in weatherstripping doors. These are difficult to install because alignment is critical to achieving a proper seal. This type is also visible when installed and subject to damage. In order to install, cut and fit strips to the head of the door first. The male strip should go on the door and the female strip on the head and hinge side of the door. A male strip should also go on the jamb. No unusual tools are required to do this job--just a hack saw, hammer and nails, and a tape measure.

Fitted interlocking metal channel is an excellent weather stripping. It forms an exceptionally good weather seal, is invisible when installed and is not exposed to possible damage. It is very difficult to install and should be installed by a carpenter.

Flat thresholds are sometimes weatherized by installing a sweep. However, a sweep may drag on the carpet or rug. Some sweeps are installed on the inside of the door and some on the outside. Check the instructions for your particular kind. Installation is simple. With a hack saw, cut the sweep to fit 1/16 inch in from the edge of the door, then attach to the door with screws.

2. Storm Doors

Consider storm doors. While 10 to 15 percent of the purchase price of combination (windows and screen) storm doors may be saved if installed by the homeowner, such an installation is difficult unless one is a relatively skilled carpenter. Much trouble and frustration may be saved by hiring a supplier to install them. A combination storm door can be installed by an experienced worker in less than half a day. Before the installer leaves check for the following:

a. Fitting

(1) The door should open smoothly and fit tight.

(2) There should not be wide cracks around the door jamb. The seal should be as air-tight as possible.

(3) The exchangeable window and screen panels should fit properly and seal tight.

b. Desirable Features

Storm doors can be purchased that are made of aluminum, steel, or wood. Your choice is primarily a matter of taste. However, there are several factors that should be considered in selecting and judging the quality of a storm door.

(1) Finish: Plain aluminum will oxidize. This will reduce the ease of operation of the door as well as detract from its appearance. Therefore, a baked enamel or anodized finish is more desirable.

(2) Weatherstripping: Weatherstripping is very important if a storm door is to fulfill its function of reducing air leakage around doors. Therefore, compare the weatherstripping of several different doors.

(3) Corner Joints: The corners should be strong and air tight. You should not be able to see through the joints. If you can, they will leak air.

(4) Hardware: The locks and hinges have a very direct effect on the durability of the storm door. Also, they are good indicators of the general quality of the door.

B. Windows

Windows should be located in such a manner to receive as much sun as possible in areas of the country where the climate is relatively cool for many months. In tropical climates, however, windows should be positioned in such a manner that they will receive little sun. Thermopane may be relatively expensive, but savings in heat loss may pay for the added cost in a few years by retaining heat or cold, depending upon the requirement.

Weatherstripping a window is similar to weatherstripping a door. (Refer to that section.)

The simplest method of obtaining good weatherization for your windows is to simply tack sheets of plastic over the outside of your windows. If you prefer, the plastic can be taped over the inside of the window. Whether you install the plastic on the inside or on the outside, be sure that all possible air leaks around the moveable parts of the window are blocked.

Inside installation is more desirable because the plastic is less likely to be damaged. Inside installation is also easier. In either case, the plastic should be stretched tightly. In addition to better appearance, tightly stretched plastic will be less susceptible to deterioration.

When ready to buy the plastic, measure the width of the largest window. Then measure the length of each window to be covered in order to determine the number of linear feet of plastic that will be required. The polyethylene plastic sheets (in rolls or kits) should be six mills thick.

If installing the plastic inside, the only tools and materials needed will be shears for cutting and trimming the plastic and 2" wide masking tape. If installing the plastic on the outside, a hammer, tacks, and 1/4" X 11/4" wood slats, to tack over and around the edge of the plastic in order to keep the tacks from tearing the plastic sheets, will be needed.

Single-pane storm windows are as effective as double-track or triple-track combination windows and are less expensive. The main disadvantage is that these can't be opened once they are installed.

If relatively skilled, a person can make single- pane storm windows by purchasing aluminum do-it-yourself materials from any hardware store. Or, the owner can measure your windows and then have a storm window supplier build them. In either case, it is extremely important that careful measurements be made. After deciding how the storm windows are to be placed in the window frame, measure around the outside of the window frame where the storm window will sit. For clearance, allow 1/8" along each side of the storm window. Fix the storm windows in place with moveable clips so they can easily be removed each summer.

In judging the quality of single-pane storm windows there are two important things to look for: the frame finish, and weatherstripping. If the finish is plain aluminum, it will oxidize quickly and degrade the appearance somewhat. An anodized or baked enamel finish is preferable. The side of the aluminum frame that touches the window frame should have a permanently installed weather strip of gasket to seal the crack between the window frame and the frame of the storm window. Leave weep holes open at the bottom.

Combination storm windows are more desirable than single-pane storm windows because they can be opened anytime.

Triple-track combination (windows and screen) storm windows are designed for installation over double hung windows. They are permanently installed and can be opened anytime with a screen to slide into place for ventilation.

Double-track combination units are also available and they can cost much less. Both kinds are sold almost everywhere and can be bought with or without the cost of installation.

Although approximately 10 to 15 percent of the purchase price of the storm windows can be saved if the homeowner installs them, only a relatively skilled carpenter should attempt the job.

While several weeks may be required for the supplier to make up the order, installation is relatively fast. A skilled worker may take only a day or so to install combination storm windows. Once the storm windows are installed, be sure that both the window sashes and screen sash move smoothly and seal tightly when closed. Also, make certain that there is a tightly caulked seal around the edge of the storm windows.

The quality of combination storm windows may be reflected in the frame finish, corner joints, sash tracks, and weatherstripping. As noted earlier, a plain aluminum finish will oxidize and thus reduce the ease of operation. Therefore, a baked enamel finish is better. Check the corners of the storm windows--they should be strong and airtight. Usually overlapping corner joints are better than mitered joints. Additionally, examine the weatherstripping in order to determine its quality. Another factor that is important is the sash track. Deep sash tracks are better in reducing air leaks than shallow tracks.

C. Caulking

Where should caulking be done?

Caulking should be used wherever two different materials or parts of a house meet. Specifically, a house should be caulked:

a. At joints between window frames and siding.

b. Between window drip caps (tops of windows) and siding.

c. Between window sills and siding.

d. At corners formed by siding.

e. At sill where wood structure meets the foundation.

f. Around outside water faucets, or other special breaks in the outside house surface.

g. Where pipes, wires and ducts penetrate the ceiling below an unheated attic.

h. Between porches and main body of the house.

i. Where chimney or masonry meets siding.

j. Where storm windows meet the window frame, except for drain holes at window sill.

k. If there is a heated attic, where the wall meets the eave at the gable ends.

There are several different types of caulking compounds. NOTE: those that have a lead base are not recommended because of the toxic nature of lead. Three types of caulking compounds that can be considered are (1) oil- or resin-based, (2) latex-, butyl-, or polyvinyl-based, (3) or elastomeric caulks. All three types will bond to most surfaces such as masonry, wood, and metal. The elastomeric caulks are the most expensive, but they are also the most durable. Latex, butyl, or polyvinyl-based caulks are less expensive and also less durable. The oil or resin based caulks are the least expensive but they are also the least durable.

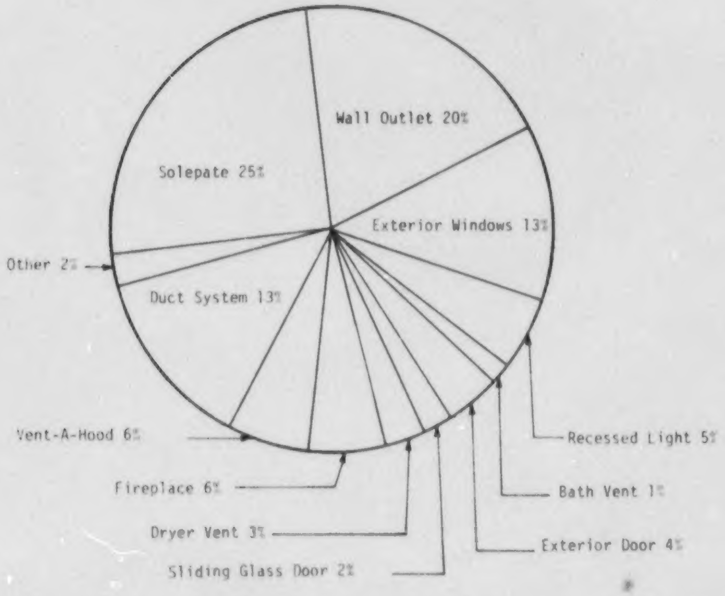
For filling wide cracks, some type of filler such as caulking cotton, oakum, glass fiber strips, or sponge rubber will be required.

In caulking, the homeowner will need a ladder, a caulking gun, caulking cartridges, some type of filler such as those mentioned above, and a putty knife.

How many caulking compound cartridges will be required? Because of the varying size of cracks that must be filled, it is difficult to estimate. However, about 1/2 of a cartridge is needed for each door or window. Approximately two cartridges are required for a two-story chimney, and four cartridges for the foundation sill.

Air leakage in the home accounts for a great deal of energy loss. For an average family of four living in a home of 1,728 sq. ft., Figure 3.1 indicates the seriousness of the problem. Caulking can be the answer to this dilemma.

AIR LEAKAGE TEST RESULTS FOR AN AVERAGE SIZE HOME
OF 1728 SQ. FT.



SOURCE: Texas Power & Light Company

FIGURE 3.1

D. ENERGY CONSERVATION MEASURE

The following is a listing of energy conserving practices which the homeowner should use in the operation of the home.

(1) During the Heating Season

a. Fireplace damper--Always close when not in use. A typical house will have an air change rate of some 200 cubic feet per minute. If a fireplace damper is left open when not in use, a good deal of hot air escapes up the chimney. This can cause the air to change at an additional 200cfm, truly wasteful and completely unnecessary.

b. Thermostat setting--Set thermostat back at night. Each 1°F reduction in setting can save approximately one percent in fuel. Do not lower the temperature so much that the system must work overly long to reheat or recool the home in the morning. While away from home for an extended period, set the thermostat at 55°F. During the daytime, close bedroom dampers to reduce the temperature slightly lower than other living areas. Clean thermostats once a year to remove dust.

c. Humidity Level--High humidity makes our bodies hold heat. Dry air absorbs moisture from the skin at a rapid rate and produces a chilling effect which can only be offset by increasing air temperature. Thus, a properly humidified home is as comfortable at 68°F as a dry one at 72°F. In the winter when we want to be warmer, a humidifier may be a wise investment which will allow lowering the house temperature to save energy. A pan of water strategically located near a heating outlet will help moisturize the air if a humidifier is not available. House plants also help increase humidity by giving off moisture.

d. Window shades, drapes and blinds--closed over large glass areas can reduce heat loss through windows during the winter. On sunny winter days, however, windows should be left uncovered to let sunshine warm the house. Draperies should be insulated or lined.

e. Caulking and Weatherstripping--cracks which can form around window and door frames and where wood meets metal or masonry allow air leakage. These cracks can normally be detected by the presence of cold drafts. A standard exterior door which has a 1/8 inch crack around it loses heat through a total area of 30 square inches. This would be equivalent to having a hole in the wall 5 1/2" by 5 1/2". Keeping weatherstripping and caulking around windows or doors in good repair will help reduce this air leakage.

f. Storm Windows and Doors --can reduce heat loss through doors and windows by more than 50 percent.

g. Maintenance

1. Do not block Radiators or Registers with obstacles such as furniture, drapes, or pictures in front of heating units or registers because these reduce operating efficiency.

2. Maintain heating equipment to assure maximum operating efficiency of heating plants and minimize fuel input rate to the burner. The following should be done:

3. Clean heat exchanger surface in the furnace regularly. Dust and products of combustion can deposit on surfaces and interfere with good heat transfer.

4. Periodically check air adjustment, which should be checked periodically by a service professional. Fuel will not burn completely when there is insufficient air. Heat will be lost up the chimney with too much air.

5. Clean or replace air filters when they become loaded with dust.

6. An expert should clean and adjust the entire heating system once a year.

h. Fireplace--Use of fireplaces as a heating source can be very deceptive. A large flow of air is generated through the hearth and up the chimney by a burning fire. This is usually the air already heated by the furnace, which means that although the fireplace is heating the immediate air, it is cooling the rest of the house by expelling the warm air. This energy loss can be reduced by reducing the thermostat setting and closing doors to the rest of the house while the fireplace is in use.

Water heater--The water heater is the second largest consumer of energy in the home. It should be sized to meet the needs. Maintaining a supply of unwanted hot water wastes energy. Losses in energy can be decreased by insulating hot water pipes from the source to the point of use. Water should not be overheated, and 140°F is the recommended temperature for a house with a dishwasher. When away from home for extended periods, turn the heater down or off. If the gas pilot light is turned off, do so according to the manufacturer's instructions.

Clothes drying--Venting an electric dryer into the house in cold climates conserves heat, but can cause moisture and lint problems. A lint trap should be installed, and the practice discontinued if moisture problems occur. Gas dryers must be vented to the outside.

Electricity use--Avoid using electrical appliances, if possible, between 5 p.m. and 8 p.m. during the winter.

Windbreak planting--Protect against winter winds which increase heat loss from houses. A tall fence or a dense growth of evergreens will reduce wind impact.

(2) During the Cooling Season

Shade planting--can reduce solar heat gain of walls, windows, and roofs can be reduced by planting tall, deciduous shade trees on the east, south, and west sides of the house. In the winter, the leafless trees permit the sun to warm the house.

Thermostat setting--Set the thermostat at the highest setting which is reasonably comfortable--78°F is the recommended comfortable temperature for most people. Each degree higher setting can save about 4 percent of the air conditioning operation cost. The air conditioner should be turned off while away from home for an extended period.

Dehumidify--In the summertime to allow the operation of the air conditioner at a higher temperature, while feeling just as comfortable and saving energy.

Window shades, drapes, and blinds--should be closed on the sunny side of the house to reverse cooling loads on sunny summer days. Use light-colored window covering because dark colors absorb heat.

Storm windows--can provide substantial energy savings in the summer as well as in the winter in air conditioned homes. The storm windows form a dead air space which acts as insulation.

Keep cooling outlets free from obstacles, such as furniture, drapes, or pictures, because these can reduce efficiency of the system.

Maintain cooling equipment by cleaning filters every 30 to 60 days--Equipment manufacturer service manuals usually tell how to best clean the filters. Condenser coils should also be kept clean. In central air conditioning units with the condenser located outside, the finned surfaces of the condenser should be kept free of leaves and mud. It is also a good idea to lubricate the bearings on the blower and electric motor, and to adjust the tension on the fan belt between the motor and blower. If the manufacturer's manual does not give instructions on these maintenance procedures, a service person should be contacted.

Clothes drying--in the summertime, require venting the hot air to the outside of the house to reduce moisture and heat in the home.

Electricity use--should be avoided, if possible, between 1 p.m. and 5 p.m. during the summer.

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

POSTTEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. Storm windows placed over single-pane windows can reduce heat loss by _______ percent.

    a. 5-10
    b. 10-15
    c. 2-30
    d. 40-60

2. A single-pane window, with a typical U factor of 1.13, has a heat loss that is more than 10 times greater than a wall having a typical U factor of 0.10.

    a. true   b. false

3. With all things being equal, a one-story, rectangular house will have more heat loss than a two-story house.

    a. true   b. false

4. There is no one national building code that applies everywhere in the nation.

    a. true   b. false

5. The biggest single influence on heating energy consumption is the occupants.

    a. true   b. false

6. The larger the R factor, the better the insulating material resists the flow of heat.

    a. true   b. false

7. The K and U factors differ from the R factor in that a small K or U factor is advantageous.

    a. true   b. false

8. If you compare K factors, remember, the larger the K factor, the better.

    a. true   b. false

9. The heat loss per square foot is the least important factor to consider when determining the amount of insulation to install.

    a. true   b. false

10. The average amount of glazing found in most homes is 15 percent of the floor area.

    a. true   b. false

11. There are many ways to effectively weatherize doors.

    a. true   b. false

12. As much as 75 percent of the heat loss in a house is through the ceiling in the winter.

    a. true   b. false

13. The temperature difference between the inside and outside of the home is not really important in determining how much insulation should be used.

    a. true   b. false

14. In most instances, there is little benefit to be gained by adding more than 4 inches of insulation.

    a. true   b. false

15. In the states of the far north, an R value of 30 is usually recommended for ceiling insulation.

    a. true   b. false

16. Heat can be transferred by only one means.

    a. true   b. false

17. It is often more economical to have a professional to install your storm doors.

    a. true   b. false

18. As far as insulation is concerned, the K factor for corkboard is very good.

    a. true   b. false

19. Elastomeric caulking compounds are the most durable caulking compounds.

    a. true   b. false

20. Sheets of plastic should never be used in weatherizing windows.

    a. true   b. false

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

ANSWERS TO POSTTEST

1. d. 40-60
2. a. true
3. b. false
4. a. true
5. a. true
6. a. true
7. a. true
8. b. false
9. b. false
10. a. true
11. a. true
12. a. true
13. b. false
14. a. true
15. a. true
16. b. false
17. a. true
18. a true
19. a. true
20. b. false

BREAKDOWN OF HEATING AND COOLING LOADS
FOR CHARACTERISTIC HOUSE USED IN HUD STUDY

COMPONENTS	% OF HEATING LOAD	% OF COOLING LOAD
CEILING	3.7	2.3
FLOOR	2.2	2.4
TOTAL WINDOW	13.6	4.1
TOTAL DOOR	1.4	0.4
TOTAL WALL	23.9	14.2
INFILTRATION LOAD	55.2	41.5
INTERNAL LOAD	--	35.1
	100.0	100.0

FIGURE 1.1

BUILDING CODE CHECKLIST

ITEM	CODE REQUIREMENTS		CAN YOU MEET IT?	
	YES	NO	YES	NO
1. Minimum area of lot (lot size)				
2. Number of families permitted				
3. Minimum or maximum house area				
4. Building height and set-back restrictions				
5. Foundation type (Is masonry required?)				
6. Is post and beam framing permitted?				
7. Is grade stamped lumber required for framing (i.e., new and kiln dried)?				
8. Minimum room sizes				
9. Minimum door sizes and number of exists				
10. Window sizes and ventilation requirements				
11. Forced ventilation for kitchen and baths				
12. Fire retardant enclosure for exitways				
13. Fire alarm system				
14. Riser and tread sizes for stairs				
15. Minimum insulation requirements				
16. Chimney clearances (Is prefab allowed?)				
17. Can owner finish a shell by contractor?				
18. Can attic or some rooms be left unfinished?				

The above list is by no means comprehensive. It is intended to call to your attention the most likely code restrictions that might adversely affect your construction of a house or remodeling of an existing building.

SOURCE: National Association of Homebuilders

FIGURE 1.2

SUGGESTED SUN ORIENTATION

	N	NE	E	SE	S	SW	W	NW
Bedrooms	X	X	X	X	X	X		
Living				X	X	X	X	
Dining			X	X	X	X	X	
Kitchen			X	X	X	X		
Library	X	X						X
Laundry	X	X						X
Play				X	X	X	X	
Drying yd.				X	X	X	X	
Bathrooms	X	X	X	X	X	X	X	X
Utility	X	X						X
Garage	X	X	X	X	X	X	X	X
Workshop	X	X						X
Terraces			X	X	X	X	X	
Sun Porch				X	X	X	X	

FIGURE 2.1

K FACTORS FOR COMMON BUILDING MATERIALS

MATERIAL	THICKNESS	K FACTOR
Cork board	1"	0.27
Fiberglass	1"	0.27
Glass foam	1"	0.40
Polystyrene foam	1"	0.15
Rock wool	1"	0.29
FIR	1"	0.67
PINE, SOFT	1"	0.86
PARTICLE BOARD	1"	0.50
SAWDUST	1"	0.41
BRICK, FACE	1"	10.00
BRICK, COMMON	1"	5.00
GYPSUM WALL BOARD	1"	0.70
STONE	8"	0.70
STONE	12"	0.50
CINDER BLOCK	8"	0.50
	12"	0.35
CONCRETE, BLOCK	8"	0.55
	12"	0.45
CONCRETE POURED	8"	0.70
	12"	0.50

FIGURE 2.2

Resistance Values of Structural and Finish Materials, Insulations, Air Spaces, and Surface Films*

Wood bevel siding, 1/2 x 8, lapped	R-0.81
Wood siding shingles, 16", 7½" exposure	R-0.87
Asbestos-cement shingles	R-0.03
Stucco, per inch	R-0.20
Building paper	R-0.06
1/2" nail-base insul. board sheathing	R-1.14
1/2" insul. board sheathing, regular density	R-1.32
25/32" insul. board sheathing, regular density	R-2.04
1/4" plywood	R-0.31
3/8" plywood	R-0.47
1/2" plywood	R-0.62
5/8" plywood	R-0.78
1/4" hardboard	R-0.18
Softwood, per inch	R-1.25
Softwood board, 3/4" thick	R-0.94

Concrete blocks, three oval cores	
Cinder aggregate, 4" thick	R-1.11
Cinder aggregate, 12" thick	R-1.89
Cinder aggregate, 8" thick	R-1.72
Sand and gravel aggregate, 8" thick	R-1.11
Lightweight aggregate (expanded clay, shale, slag, pumice, etc.), 8" thick	R-2.00

Concrete blocks, two rectangular cores	
Sand and gravel aggregate, 8" thick	R-1.04
Lightweight aggregate, 8" thick	R-2.18

Common brick, per inch	R-0.20
Face brick, per inch	R-0.11
Sand-and-gravel concrete, per inch	R-0.08
Sand-and-gravel concrete, 8 inches thick	R-0.64
1/2" gypsumboard	R-0.45
5/8" gypsumboard	R-0.56
1/2" lightweight-aggregate gypsum plaster	R-0.32
25/32" hardwood finish flooring	R-0.68
Asphalt, linoleum, vinyl, or rubber floor tile	R-0.05
Carpet and fibrous pad	R-2.08
Carpet and foam rubber pad	R-1.23
Asphalt roof shingles	R-0.44
Wood roof shingles	R-0.94
3/8" built-up roof	R-0.33

Glass	
Single glass (winter)	U = 1.13
Single glass (summer)	U = 1.06
Insulating glass (double)	
1/4" air space (winter)	U = 0.65
1/4" air space (summer)	U = 0.61
1/2" air space (winter)	U = 0.58
1/2" air space (summer)	U = 0.56
Storm windows	
1" to 4" air space (winter)	U = 0.56
1" to 4" air space (summer)	U = 0.54

Insulation	
2" – 2½" thick	R-7.00
3" – 4" thick	R-11.00
5" – 7" thick	R-19.00

Air Spaces (3/4")	
Heat flow UP	
Non-reflective	R-0.87
Reflective, one surface	R-2.23
Heat flow DOWN	
Non-reflective	R-1.02
Reflective, one surface	R-3.55
Heat flow HORIZONTAL	
Non-reflective (also same for 4" thickness)	R-1.01
Reflective, one surface	R-3.48

Note: The addition of a second reflective surface facing the first reflective surface increases thermal resistance values of an air space only 4 to 7 per cent.

Surface Air Films	
INSIDE (still air)	
Heat flow UP (through horizontal surface)	
Non-reflective	R-0.61
Reflective	R-1.32
Heat flow DOWN (through horizontal surface)	
Non-reflective	R-0.92
Reflective	R-4.55
Heat flow HORIZONTAL (through vertical surface)	
Non-reflective	R-0.68
OUTSIDE	
Heat flow any direction, surface any position	
15 mph wind (winter)	R-0.17
7.5 mph wind (summer)	R-0.25

Example calculations
(to determine the U value of an exterior wall)

Wall Construction	Uninsulated Wall Resistance	Insulated Wall Resistance
Outside surface (film), 15 mph wind	0.17	0.17
Wood bevel siding, lapped	0.81	0.81
½" ins. bd. sheathing, reg. density	1.32	1.32
3½" air space	1.01	
R-11 insulation		11.00
½" gypsumboard	0.45	0.45
Inside surface (film)	0.68	0.68
Totals	4.44	14.43

For uninsulated wall, $U = \frac{1}{R} = \frac{1}{4.44} = U = 0.22$

Therefore, heat loss for the above uninsulated wall section at a +10° F. outside design temperature is equal to 0.22 x 60 (or 70-10) equals 13.2 Btuh per sq. ft. of wall section.

For insulated wall, $U = \frac{1}{R} = \frac{1}{14.43} = U = 0.07$

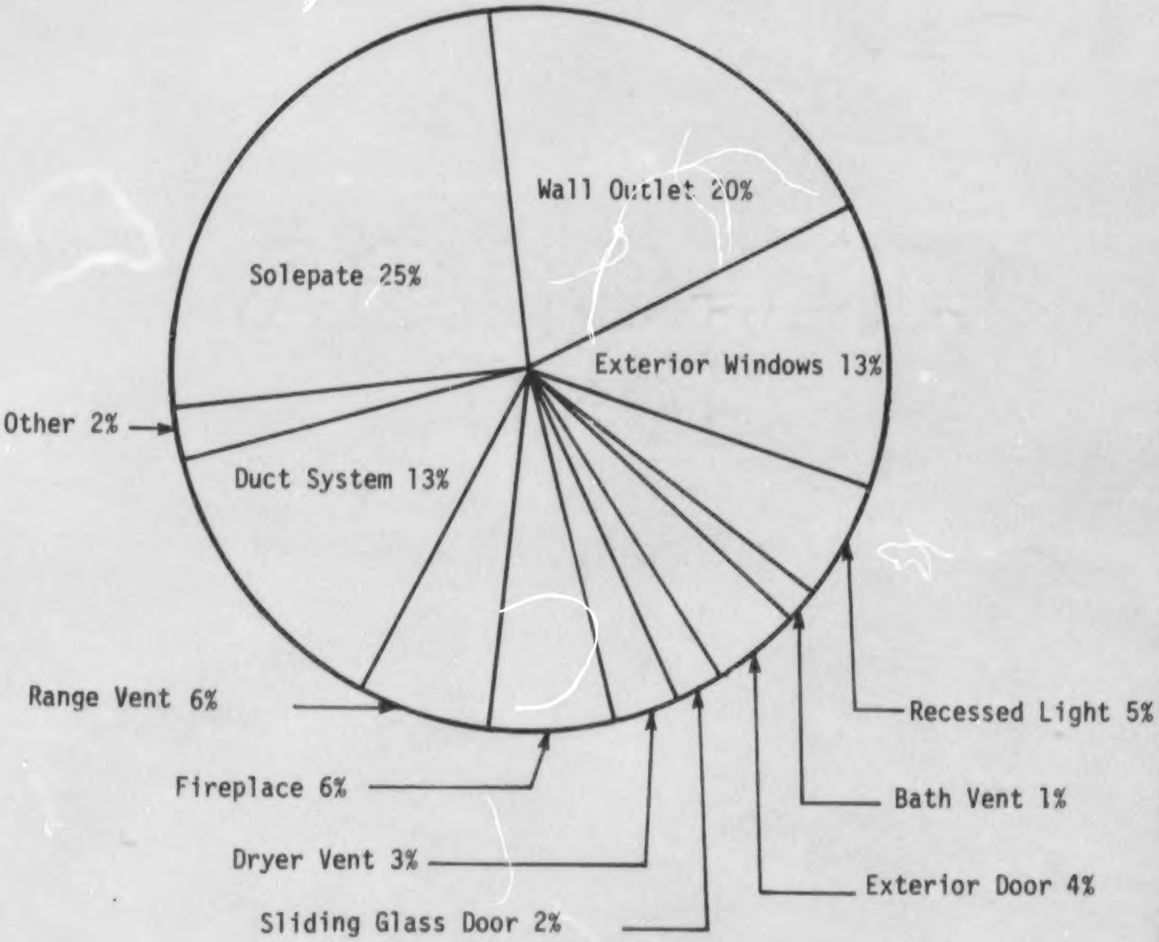
Therefore, heat loss for the above insulated wall section at a + 10° F. outside design temperature is equal to 0.07 x 60 (or 70-10) equals 4.2 Btuh per sq. ft. of wall section.

---

* Additional resistance values can be obtained from ASHRAE Handbook of Fundamentals published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers.

FIGURE 2.3

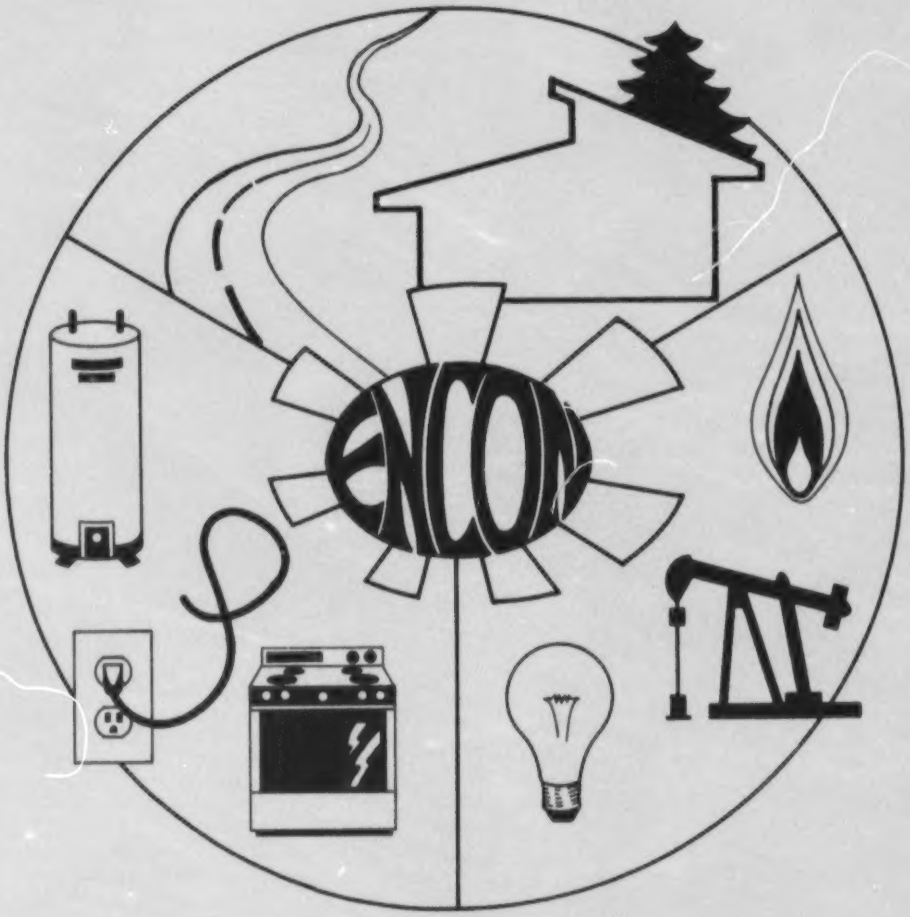
AIR LEAKAGE TEST RESULTS FOR AN AVERAGE SIZE HOME
OF 1728 SQ. FT.



SOURCE: Texas Power & Light Company

FIGURE 3.1

ENERGY CONSERVATION
FOR VOCATIONAL STUDENTS



STUDENT MATERIALS

NAVARRO COLLEGE
CORSICANA, TEXAS

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT IV

STUDENT WEATHERIZATION WORKBOOK

LECTURE	ACTIVITIES

INTRODUCTION

The student weatherization workbook is intended for student use in surveying the home and calculating heat gain and heat loss through various features in building construction. It is a culmination of all lecture material covered in this module and is meant as a teaching tool through the above units.

MODULE VIII

BUILDING CONSTRUCTION VERSUS ENERGY CONSUMPTION

UNIT IV

WEATHERIZATION WORKBOOK

UNIT OBJECTIVES

1. Survey the home and compute for heat loss by infiltration.
2. Survey the home and compute for heat loss by conduction through floors.
3. Survey the home and compute for heat loss by conduction through ceilings.
4. Survey the home and compute for heat loss through single-glass windows.
5. Survey the home and compute for heat loss through double-glass or plastic-covered windows, and through doors.
6. Survey the home and compute for heat losses through walls.
7. Calculate cost savings for implementing conservation measures in each of the above areas.

Description of Building

Sketch all views and put dimensions on each part shown, for example, length of walls, width and length of windows, etc. Label all single glass windows S and double glass and doors D . Complete all items in the job book labeled "Fill in at Job Site."

Front View

Right Side View

Left Side View

Rear View

Plan View

These grids are provided as guides for lines. Drawings need not be done to scale.

Calculation of Floor Area

☐ x ☐

Building length ft.

Building width ft.

= ☐

Floor area sq.ft.

FILL IN
AT JOB SITE

Description of Building

Dwelling Unit Information

Name of Head of Household

____

Name and Address of Owner:
(if not the same as above)

____
____
____
____

Occupants of Structure:

☐ Total number

Style of Structure:

☐ One-story
☐ Two-story
☐ 2-1/2 story
☐ Split-level
☐ Other (specify) ______________

Age of Structure (approx.): ________ years

Rooms in Living Space:

☐ Total number of rooms
☐ Number used in winter

Occupants Comments (drafty, cold floors, too expensive to heat):

____
____
____
____
____
____

FILL IN AT JOB SITE

Heating System Information

Type of Fuel: (P = Primary)
(S = Secondary)

☐ Fuel oil
☐ Bottled gas
☐ Coal/coke
☐ Electricity
☐ Natural gas
☐ Wood
☐ Kerosene
☐ Other (specify) ______________

Type of Heating System: (P = Primary)
(S = Secondary)

☐ Steam/hot water/hot air
☐ Fireplace/stove/portable heater
☐ Electrical baseboard
☐ Other (specify) ______________

Domestic Hot Water:

Does central heating system provide heat for domestic hot water? ________

Thermostat Setting in Winter (average):

_____ Day _____ Night _____ None

Amount of Fuel Used Last Heating Season:

	Primary	Secondary
Type	________	________
Quantity	________	________
Total Cost	$________	$________

District Heating Factor ______________
(see page 14)

Heat Loss by Infiltration

On pages 4-9, calculate the heat loss by infiltration and by conduction through the separate parts of the building; enter the results in the table at the bottom of each page and in the summary table on page 10.

House Draft Index: Opposite each of the four component parts of a building in the table below, place a check mark in the circle adjacent to the features which best describe the condition of the building.

Building Component	**One** Air change per hour ①	**Two** Air change per hour ②	**Three** Air change per hour ③
Cellar **or** **Crawl Space**	Tight, no cracks, caulked sills, sealed cellar windows, no grade entrance leaks Plywood floor, no trap door leaks, no leaks around water, sewer, and electrical openings ○	Some foundation cracks, loose cellar windows, grade entrance not tight Tongue-and-groove board floor, reasonable fit on trap doors, around pipes ○	Major foundation cracks, poor seal around grade entrance Board floor, loose fit around pipes ○
Windows	Storm windows with good fit ○	No storm windows, good fit on regular windows ○	No storm windows, loose fit on regular windows ○
Doors	Good fit on storm doors ○	Loose storm doors, poor fit on inside door ○	No storm doors, loose fit on inside door ○
Walls	Caulked windows and doors, building paper used under siding ○	Caulking in poor repair, building needs paint ○	No indication of building paper, evident cracks around door and window frame ○

FILL IN AT JOB SITE

Multiply the number of check marks in the first column by 1, the second column by 2, and the third column by 3. The Draft Index will be the sum of these products, divided by 4.

☐	x	☐	=	☐
Floor area sq.ft.		Height to ceiling (to upstairs ceiling in two-story house) ft.		Volume of air in building cu.ft.

☐	x	☐	x	☐	x.02 =	▨
Volume of air in building		Draft index		District heating factor		**Heating units required**

Potential Savings by Reducing Infiltration
It should be possible to reduce the draft index for a building to 1 (that is, reduce the number of air changes to one per hour). If the draft index for this building were improved to 1, the infiltration loss would be:

☐	x	1	x	☐	x.02 =	☐
Volume (from above)		Draft index		District heating factor		Potential heating units

Subtract the potential heating units from those now required and enter here →

Type of Heat Loss	**Heating Units Required**	**Potential Heating Savings**	**Proposed Changes to Structure**	**Heating Units to be Saved**
Infiltration	▨			

Heat Losses by Conduction Through Floors

Floor Exposure Factor

Select the appropriate factor from the descriptions below:

Building on posts or pillars with no skirts below floor	1.0
Crawl space skirted	.8
Rock wall basement	.8
More than 2 feet of basement wall exposed above grade	.8
Building on slab	.5
Building with tight crawl space	.5
Building with tight basement (heated or unheated)	.5

R value of floor

List below all materials in floor deck, including carpet but not floor joists, starting from uppermost surface and working down.

Insert R value for each component from Table 1 (p. 15)

Material	Thickness (inches)	R Value
Interior surface	—	0.68
Interior surface	—	.68
	Total R value	

FILL IN AT JOB SITE

	x		x		÷		=	▨
Floor area (from building description) sq.ft.		Floor exposure factor		District heating factor		Total R value		Heating Units Required

Potential Savings on Floor Heat Losses

Floors can sometimes be insulated to reduce heat loss but this is often difficult; where water pipes are below the floor, freezing problems may occur during very cold spells. However, every floor should be protected from drafts, so that it has a floor exposure factor of 0.5. With this exposure factor for this building, the heat loss through the floor would be:

	x	0.5	x		÷		=	
Floor area from above sq.ft.		Floor exposure factor		District heating factor		Total R value from above		Potential heating units

Subtract the potential heating units from those now required and enter here

Type of Heat Loss	Heating Units Required	Potential Heating Savings	Proposed Changes to Structure	Heating Units to be Saved
Conduction Through Floors	▨			

Heat Losses by Conduction Through Ceilings

Area of Ceiling

(Take area of upstairs ceiling in a two-story house)

Ceiling area will normally be the same as floor area (from building description sheet)

☐
Distance between joists/rafters:

Material	Thickness (inches)	R Value
Inside surface	—	0.68
Inside surface (0.68) — OR — Outside surface (0.17)	— —	
	Total R value	

FILL IN AT JOB SITE

☐	x	☐	÷	☐	=	☐
Ceiling area sq.ft.		District heating factor		**Total R value**		**Heating units required**

Potential Savings by Insulation of Ceilings

A well-insulated ceiling (with 6 inches of insulation) should have an R value of 20. If the R value were 20 for this building, the ceiling heat loss would be:

☐	x	☐	÷	20	=	☐
Ceiling area sq.ft.		District heating factor		Total R value		Potential heating units

Subtract the potential heating units from those now required and enter here

Type of Heat Loss	Heating Units Required	Potential Heating Savings	Proposed Changes to Structure	Heating Units to be Saved
Conduction Through Ceilings				

Heat Losses by Conduction Through Single-Glass Windows

Area of Single Glass Windows:

(Assuming R = 1 for single glass)

If none, enter 0 and go to next sheet on double windows and doors

Width x	Height x	Number =	Area

Total sq.ft. ☐

☐ x ☐ = ▨

Total sq.ft. x District heating factor = Heating units required

Potential Saving by Double Glazing

Double glazing or adding storm windows will cut the heat loss by half, so divide heating units by two, and enter here

Type of Heat Loss	Heating Units Required	Potential Heating Savings	Proposed Changes to Structure	Heating Units to be Saved
Conduction Through Single-Glass Windows	▨			

Heat Losses by Conduction Through Double-Glass or Plastic-Covered Windows and Through Doors

Area of Double Glass and Doors

(Assuming R = 2 for these units)

Width x	Height x	Number =	Area
		Total sq.ft.	

	x		÷	2	=	
Total sq.ft.		District heating factor		R value		Heating units required

Potential Savings

Triple glazing of windows can be done but is not usually practical. If no change were made in the windows, the potential saving would be 0 heating units and should be entered here

(If windows were triple glazed, the R value would be approximately 3, and the potential savings would be one-third of the "Heating Units Required.")

Type of Heat Loss	Heating Units Required	Potential Heating Savings	Proposed Changes to Structure	Heating Units to be Saved
Conduction through Doors & Double-Glass Windows				

Heat Losses by Conduction Through Walls

R Value of Outside Walls

List below all materials in walls, starting from inside and including air spaces within the wall. Insert R value for each component from Table 1.

Material	Thickness (inches)	R Value
Interior surface	—	0.68
Outside surface	—	.17
	Total R value	

FILL IN AT JOB SITE

	x		=	
Total perimeter of outside wall ft.		Total height of outside wall ft.		Gross wall area sq.ft

	−		=	
Gross wall area sq.ft		Total area of all windows and doors (from previous two pages) sq.ft.		Net wall area sq.ft.

	x		÷		=	
Net wall area		District heating factor		Total R Value		Heating units required

Potential Savings by Insulation

Well-insulated walls should have an R value of 15. If this were so for this building, the wall heat loss would be:

	x		÷	15	=	
Net wall area (from box above)		District heating factor		R value		Potential heating units

Subtract the potential heating units from those now required and enter here

Type of Heat Loss	Heating Units Required	Potential Heating Savings	Proposed Changes to Structure	Heating Units to be Saved
Conduction Through Walls				

Summary Table

Use the instructions on page 11 of the Home Weatherization Manual to assess which potential savings can be obtained most successfully.

Fill out the following Summary Table by entering the "Heating Units Required" and the "Potential Heating Savings" from the corresponding tables at the bottom of pages 4-9. Then, write in the "Proposed Changes" and "Heating Units to be Saved" by such changes.

Heat Requirement Estimates (Annual Heating Units Needed)

Type of Heat Loss		Heating Units Required	Potential Heating Savings	Proposed Changes to Structure	Heating Units to be Saved
Infiltration	From Page 4				
Conduction Through Floors	Page 5				
Conduction Through Ceilings	Page 6				
Conduction Through Single-Glass Windows	Page 7				
Conduction Through Doors & Double-Glass Windows	Page 8				
Conduction Through Walls	Page 9				
	Total				

Use the space below to calculate the quantities and cost of materials needed to make the proposed changes to the building.

Job Sheet A

This Page is Removable for Use at Job Site

Name ______________________ Address ______________________

Type of Materials	Quantity Required	Estimated Cost	Location Where Materials Are To Be Installed (Walls, Ceiling, etc.)	Installation Figure No.	Special Instructions

(Insert Carbon Paper Under Table at Top of Page Only)

Map or directions for locating home:

FILL IN AT JOB SITE

Work record

Activity	Date	Supervisor	Comments
Order materials			
Install materials			

Job Sheet B

This Page is Retained With Job Book as Permanent Record

Type of Materials	Quantity Required	Estimated Cost	Location Where Materials Are To Be Installed (Walls, Ceiling, etc.)	Installation Figure No.	Special Instructions

Total Cost ☐

Pay-off Time

This is the number of seasons for fuel savings to pay off the cost of weatherization.

$$\frac{\boxed{}\ \text{Total cost (from job sheet above)}}{\boxed{} \times \boxed{} \times \boxed{}} = \boxed{}$$

Total cost
(from job sheet above)

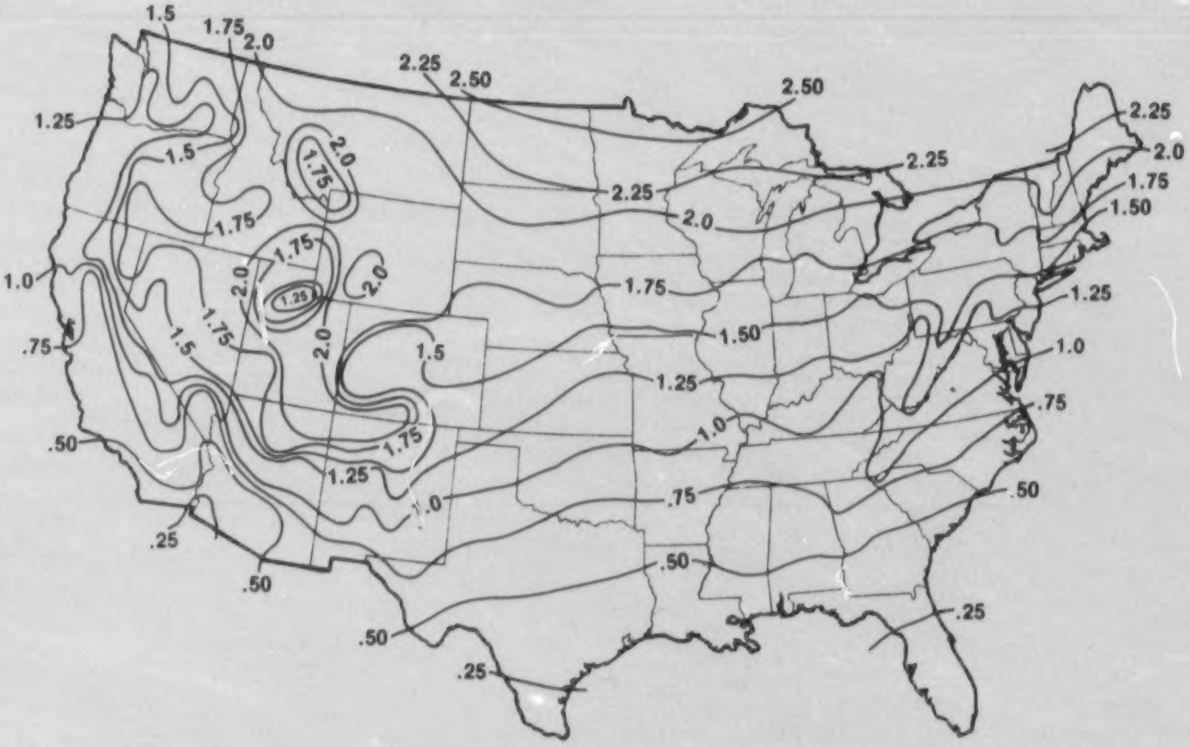
Fuel factor
Fuel oil = 1
Natural gas = 120
Electricity = 30
Wood = .01

Total
heating units
saved
(from page 10)

Price of fuel
per gal, cu.ft.,
kWh, cord

"Pay-off" time
(heating seasons)

DISTRICT HEATING FACTOR FOR THE UNITED STATES


1.5
1.75
2.0
2.25
2.50
2.50
1.25
1.5
2.0
1.75
2.25
2.25
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2.0
1.75
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1.75
1.25
1.0
.75
.50
.25
.50
.50
.25
.50
.25

Table 1: Insulation Value of Common Materials

This list is not intended to include all types of building materials, but only materials commonly used in residences. If necessary, select the material most similar, and the resulting values will not substantially affect the calculation.

MATERIAL	THICKNESS (Inches)	R VALUE
Air Film and Spaces:		
Air space, bounded by ordinary materials	¾ or more	.91
Air space, bounded by aluminum foil	¾ or more	2.17
[illegible]	[illegible]	.17
[illegible]	[illegible]	.68
Masonry:		
Sand and gravel concrete block	8	1.11
	12	1.28
Lightweight concrete block	8	**2.00**
	12	**2.13**
Face brick	4	.44
Concrete cast in place	8	.64
Building Materials — General:		
Wood sheathing or subfloor	**3/4**	**1.00**
Fiber board insulating sheathing	[illegible]	**2.10**
Plywood	5/8	.79
	1/2	.63
	[illegible]	.47
Bevel-lapped siding	**1/2 x 8**	**.81**
	3/4 x 10	1.05
Vertical tongue and groove board	3/4	1.00
Drop siding	**3/4**	**.94**
Asbestos board	**1/4**	**.13**
3/8" gypsum lath and 3/8" plaster	3/4	.42
Gypsum board (sheet rock)	3/8	.32
Interior plywood panel	**1/4**	**.31**
Building paper	—	.06
Vapor barrier	—	.00
Wood shingles	**—**	**.87**
Asphalt shingles	**—**	**.44**
Linoleum	—	.08
Carpet with fiber pad	—	2.08
Hardwood floor	**—**	**.71**
Insulation Materials (mineral wool, glass wool, wood wool):		
Blanket or batts	1	3.70
	3 1/2	11.00
	6	**19.00**
Loose fill	**1**	**3.33**
Rigid insulation board (sheathing)	3/4	2.10
Windows and Doors:		
Single window	—	approx. 1.00
Double window	**—**	**approx. 2.00**
Exterior door	**—**	**approx. 2.00**

Source: **ASHRAE** Guide and Data Book.

First printing June 1975
Second printing September 1975
Third printing December 1975
Fourth printing January 1976
Revised fifth printing May 1976

Project #1
Attic Insulation

Background

Most homes, built in the days when energy was plentiful and cheap, don't have enough insulation – but insulation can be added to any house. Insulating an attic, where savings generally will be greatest, usually can be done by the home owner himself.

In winter alone, adequate insulation in the attic could save up to 30 percent on energy costs for heating the home. In an air-conditioned home, summer savings will be comparable.

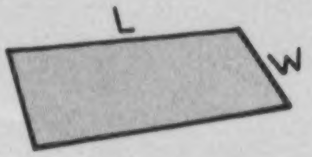
The exact amount of money you will save is affected, of course, by the rates you pay for fuel and electricity. However, no matter what those rates are, if you make energy-conserving improvements to your home now, you can expect even greater dollar savings in the future as energy costs rise with inflation.

How Big Is Your Attic?

To get your attic area, you don't even have to go up into the attic. Find out the area of the first floor of your home, not counting the garage, porch, and other unheated areas, and it will be the same as the area of your attic.

If It's A Rectangle

Measure its length and width in feet to the nearest foot and multiply them together.

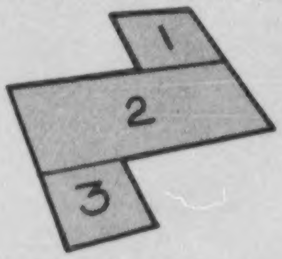


Length × Width = Area

________ × ________ = ________

If It's A Combination

Break it down into rectangles, find the area of each one, then add the areas to get the total.



Length × Width = Area

1________ × ________ = ________

2________ × ________ = ________

3________ × ________ = ________

Total Area ________

How Much Insulation Should You Have in the Attic?

Perhaps your attic already has some insulation. A representative from the power company will help examine your attic and will recommend how much additional insulation is necessary. Once you know how much insulation you will need, you can calculate the cost.

The representative will also advise you which "R" value is most appropriate for your area. (The "R" value shows the ability of insulation to slow the transfer of heat. The higher "R" values represent more insulating ability.)

If you already have this much batt insulation in the attic...	and you want to install additional batts, you will need...			
	For R-30		For R-38	
	Glass Fiber	Rock Wool	Glass Fiber	Rock Wool
0	9½"	8½"	12"	11"
2"-4"	6"	5½"	9½"	8½"
5"-6"	3½"	3"	6"	5½"

The thickness of batt insulation is measured in inches. The best way to measure the amount of additional loose-fill insulation is to refer to the number of bags. The chart below indicates the *minimum* number of bags for each 1,000 square feet of ceiling area. The bags in this chart are 25 pounds (for glass fiber) and 30 pounds (for rock wool and cellulose fiber).

If you already have this much insulation (either batts or loose-fill)...	and you want to install additional loose fill, you will need this many bags per thousand square feet...			
	For R-30		For R-38	
	Glass Fiber	*Rock Wool or Cellulose Fiber	Glass Fiber	*Rock Wool or Cellulose Fiber
0	30	62	40	77
2"-4"	22	38	30	62
5"-6"	11	23	22	45

*Varies according to bag size and material.

How To Insulate Your Unfinished Attic

Install batts or blankets between the joists or trusses in your attic.

OR

Pour in loose fill between the joists or trusses.

OR

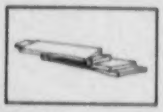
Lay in batts or pour in loose fill over existing insulation if you've decided you don't have enough already. *Don't* add a vapor barrier if you're installing additional insulation.

Safety

- ★ Provide good lighting.
- ★ Lay boards or plywood sheets down over the tops of the joists or trusses to form a walkway (the ceiling below won't support your weight).
- ★ Be careful of roofing nails protruding through roof sheathing. Wear a protective hat.
- ★ If you use glass fiber or mineral wool, wear gloves and breathing mask, and keep the material wrapped until you're ready to put it in place.
- ★ Do not cover recessed light fixtures or contact flue vents with insulation.
- ★ Do not block combustion air openings if fossil fueled heating.

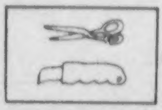
Tools

Temporary lighting.


Temporary flooring.

Duct or masking tape (2" wide).

Heavy duty staple gun and staples or hammer and tacks.


Heavy duty shears or linoleum knife to cut batts, blankets and plastic for barrier.

Caulking gun and compound.

Materials

What You'll Need

Batts: glass fiber or rock wool

OR

Blankets: glass fiber or rock wool

OR

Loose fill: rock wool, cellulose, or vermiculite

Vapor Barriers

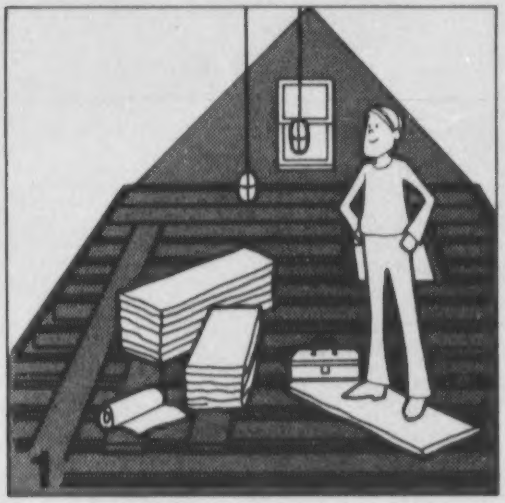
A vapor barrier will reduce the chance of water vapor condensing and collecting in your new insulation or on the beams and rafters of your house.

If you are installing batt or blanket insulation, in an uninsulated attic, you will need a vapor barrier. Buy the batts or blankets with the vapor barrier attached. Install them with the vapor barrier side toward the living space.

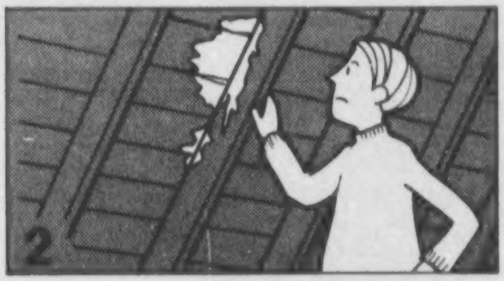
In an attic without insulation, you can also lay down polyethylene (heavy, clear plastic) in strips between the joists before you install any insulation. If you install additional insulation over existing insulation, either use poured insulation or an unfaced batt (no vapor barrier). When vapor barriers are placed between existing and added insulation, moisture is trapped, reduces the insulation value, and could cause structural damage.

Preparation

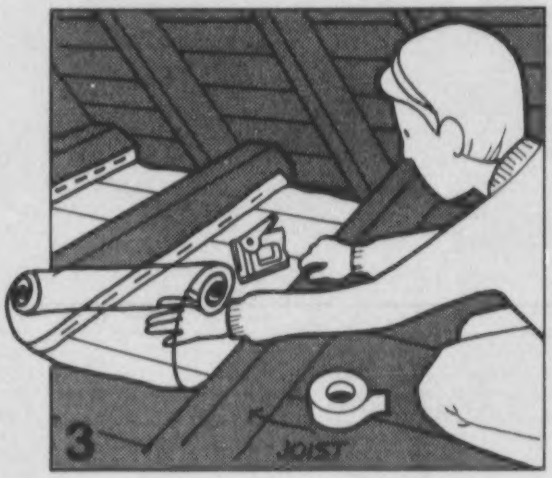
Put in temporary lighting and flooring, check for leaks and check for ventilation and vapor barrier. Caulk all places where pipes or wires penetrate the attic. Seal all open furdowns.



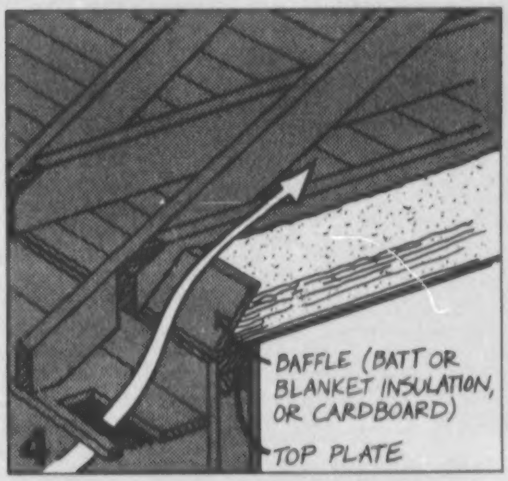
Install temporary flooring and lights. Keep insulation in wrappers until you are ready to install. It comes wrapped in a compressed state and expands when the wrappers are removed.



Check for roof leaks, looking for water stains or marks. If you find leakage, make repairs before you insulate. Wet insulation is ineffective and the moisture can damage the structure of your home.



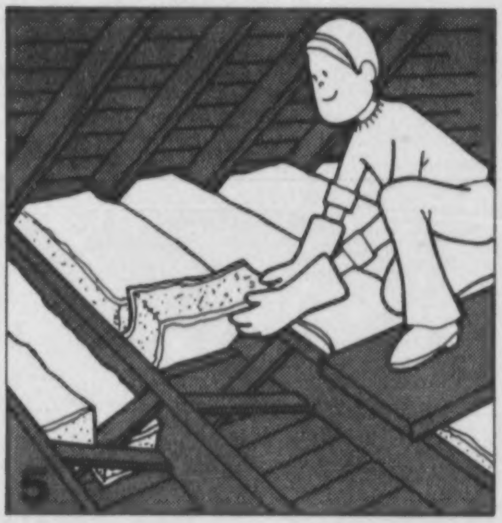
Install separate vapor barrier if needed. Lay in polyethylene strips between joists or trusses. Staple or tack in place. Seal seams and holes with tape. (Seams may be overlapped 6" instead.)



If you're using loose fill, install baffles at the inside of the eave vents so that the insulation won't block the flow of air from the vents into the attic. This is best accomplished by insulating batts around the perimeter of the attic. Be sure that insulation extends out far enough to cover the top plate.

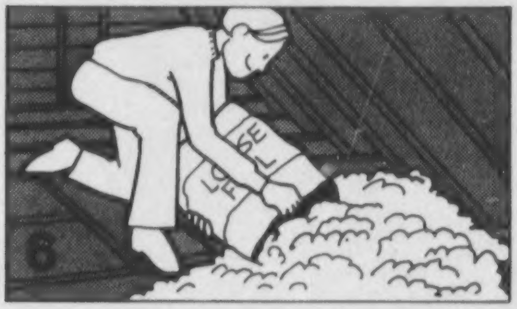
Installing the Insulation

Either lay in batts or blankets between the joists or pour in loose fill. If you're using batts or blankets with a vapor barrier, place the barrier on the side toward the living area.

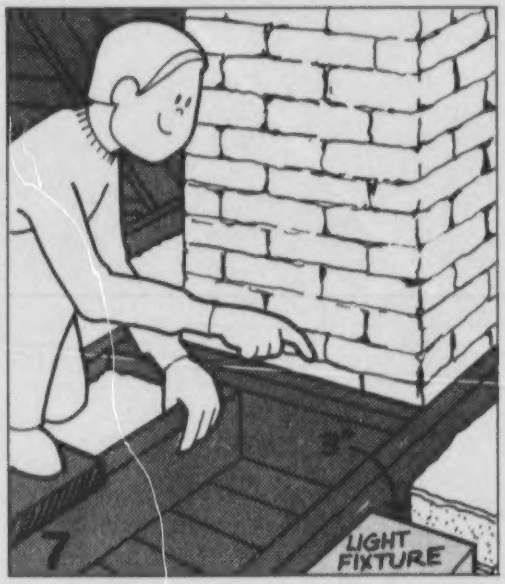


Lay in blankets or batts between joists or trusses. (Note: batts and blankets are slightly wider than joist spacing so they'll fit snugly.) If blankets are used, cut long runs first to conserve material, using leftovers for shorter spaces

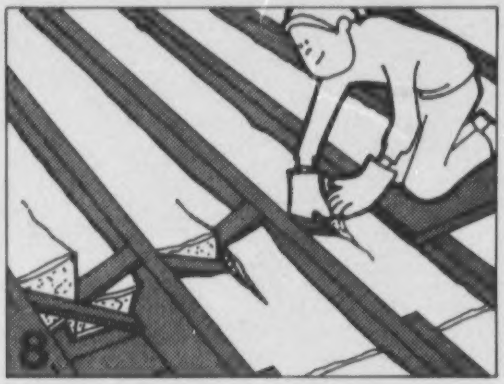
OR



Pour in loose fill insulation between the joists. Fill all the nooks and crannies but don't cover recessed light fixtures or exhaust fans.



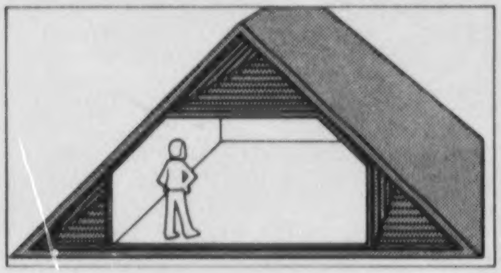
The space between the chimney and the wood framing should be filled with *non-combustible* material, preferably unfaced batts or blankets. Also, the National Electric Code requires that insulation be kept three inches away from recessed light fixtures.



Cut ends of batts or blankets to fit snugly around cross bracing and electric wiring. Cut the next batt in a similar way to allow the ends to butt tightly together.

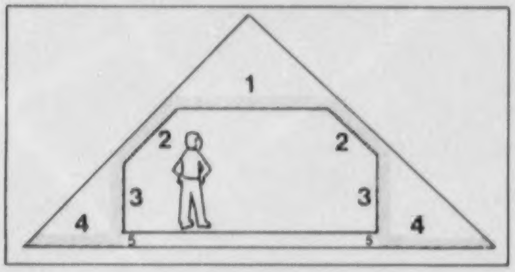
How To Insulate Your Finished Attic

General



Some homes have attics that are completely or partially finished. This attic area should be insulated with the same amount of insulation as an unfinished attic. Some of the areas that need insulation may be difficult to get to. Since there are so many variations, it would be a good idea to check with your power company representative or a contractor to get specific suggestions for your own home. Here are some general guidelines for those areas where insulation will improve the comfort and energy efficiency of a home.

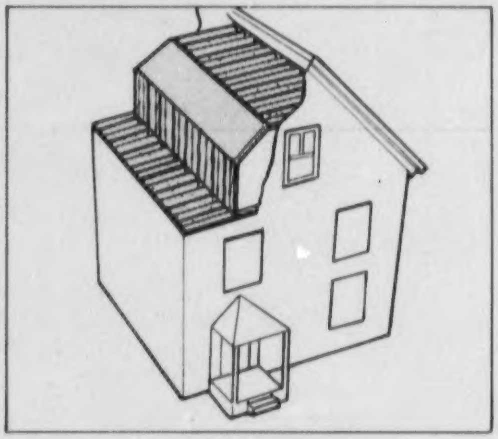
Where You Need Insulation



1. Attic ceiling
2. Rafters (be sure to leave at least an inch of space between the insulation and the roof for proper attic ventilation)
3. Knee walls
4. Outer attic floors
5. Block openings

Types of Insulation

For all vertical and sloping surfaces, you will have to use batt insulation. You can use either batts or blown insulation for the horizontal areas like the attic ceiling or attic floors.



Project #2 Floor Insulation

How To Insulate the Floor Area

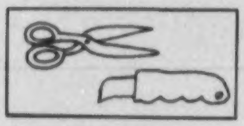
Floors over unheated areas, such as crawl spaces, garages, or basements, can be a major source of heat loss in an otherwise well-insulated house. The main goal in this project is to protect floors which are exposed to the outside.

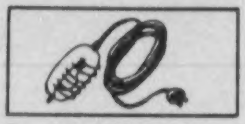
The job is quite easy to do in most cases. If you are insulating over a crawl space there may be some problems with access or working room, but careful planning can make things go much more smoothly and easily.

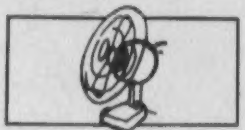
Safety

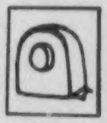
- ★ Provide adequate temporary lighting
- ★ Wear gloves and breathing mask when working with glass fiber or rock wool
- ★ Provide adequate ventilation
- ★ Keep lights and all wires off wet ground
- ★ It would be good to inspect for insects, bees, wasps, and so forth under the house. Use a spray, insecticide, or other necessary protection.

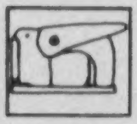
Tools


Heavy duty shears or linoleum knife.

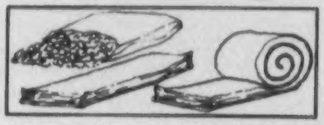

Temporary lighting with connectors.

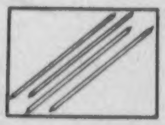

Portable fan or blower to provide ventilation.

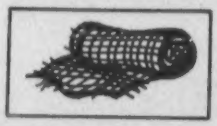

Tape measure.

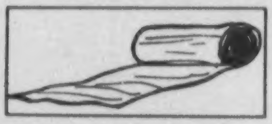

Heavy duty staple gun and staples.

Materials


R-19 (6") batts or blankets or rock wool or glass fiber, preferably with foil facing.


Metal insulation support rods.


Or wire mesh or chicken wire of convenient width for handling in tight space.

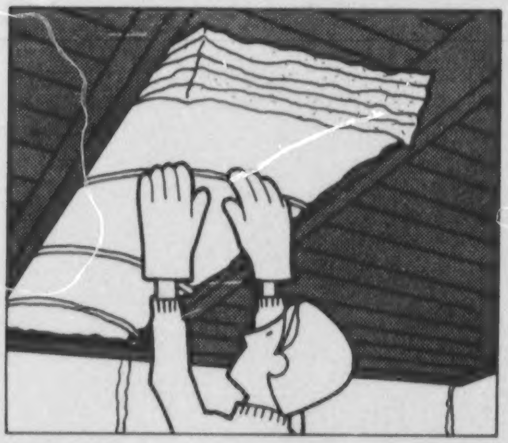

6 mil polyethylene sheets (if the insulation does not have a vapor barrier.)

How Much

See page 5. You figure the area as you would your attic space.

Installation

One way to install batts or blankets between the floor joists is by stapling wire mesh or chicken wire to the bottom of the joists and sliding the batts or blankets in on top of the wire. (If a polyethylene vapor barrier is used, apply this in strips between the joists first.)

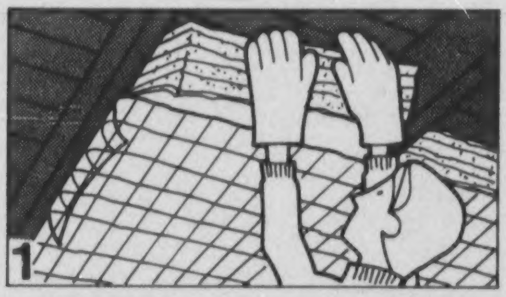


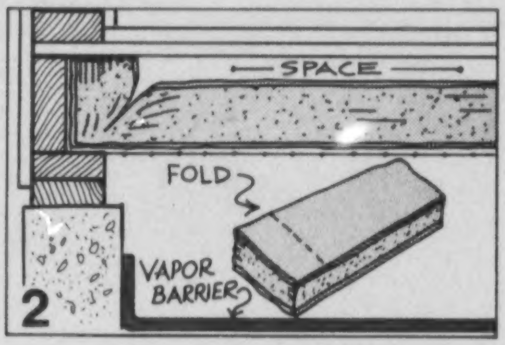
An easier way is to use insulation supports, which are metal rods the size of coat hanger wire. Check your floor joist spacing – this method will work best with standard 16" or 24" joist spacing. If you have non-standard or irregular spacing there will be more cutting and fitting and some waste of material.

Uncovered Ground in Crawl Space

Lay a vapor-resistant ground cover, such as 4- or 6-mil polyethylene film, on the ground in the crawl space to stop the rise of water vapor from the ground. Provide foundation vents to let the moisture escape from the crawl space.

Start at a wall at one end of the joists and work out. Staple the wire to the bottom of the joists and at right angles to them. Slide batts in on top of the wire. Work with short sections of wire and batts so that it won't be too difficult to get the insulation in place. Plan sections to begin and end at obstructions such as cross bracing.





Insulation backed by vapor barrier is recommended. Install the vapor barrier facing up toward the inside of the house. Be sure to fold the ends of the batts to fit snugly up against the bottom of the floor to prevent loss of heat. Don't block combustion air openings for furnaces or other flame-type appliances.

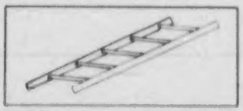
Project #3
Window Improvements

How To Caulk the Windows

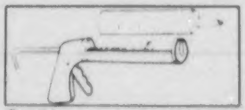
To keep your house sealed tightly during the heating and cooling months, you should make sure that the windows and doors are properly weatherstripped and caulked. This project concentrates on increasing the energy efficiency and comfort of the home. Single-pane windows often cause drafts, chilly areas, condensation and moisture problems.

Caulking should be applied wherever two different materials or parts of the house meet. It takes no specialized skill to apply and a minimum of tools.

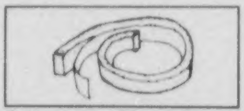
Tools



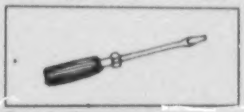
Ladder.



Caulking gun and cartridges.



Oakum, glass fiber strips, caulking cotton, or sponge rubber.



Putty knife or large screwdriver.

Safety

- ★ You'll need to use a ladder to reach some of the areas which need to be caulked. Be sure you use it safely.
- ★ Level and block the ladder in place. Have a helper hold it if possible.
- ★ Don't try to reach that extra little bit – get down and move the ladder.
- ★ Carry your caulking gun with a sling so that you can use both hands climbing the ladder.

Materials

Caulking compound is available in these types:

Oil or resin base caulk–readily available and will bond to most surfaces – wood, masonry and metal; not very durable but lowest in first cost for this type of application.

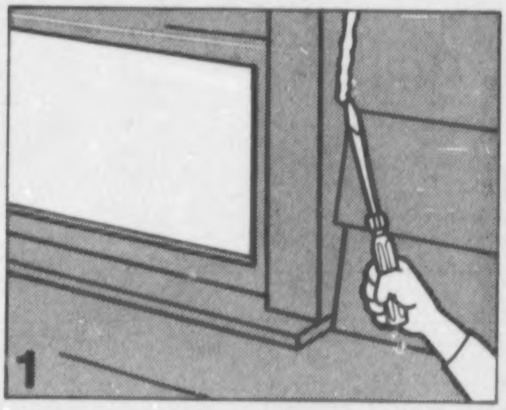
Latex, butyl or polyvinyl based caulk–all readily available and will bond to most surfaces, more durable, more expensive than oil or resin based caulk.

Elastomeric caulks–most durable and most expensive, includes silicones, polysulfides and polyurethanes; the instructions provided on the labels should be followed.

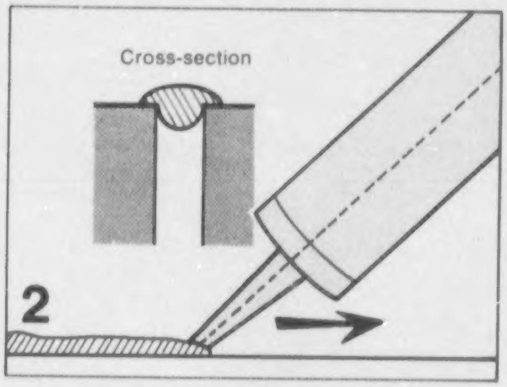
Filler–includes oakum, caulking cotton, sponge rubber, and glass fiber types; used to fill extra wide cracks or as a backup for elastomeric caulks.

Estimating the number of cartridges of caulking compound required is difficult since the number needed will vary greatly with the size of cracks to be filled. You will need approximately a half cartridge per window. If possible, it's best to start the job with a half-dozen cartridges and then purchase more as the job continues and you need them.

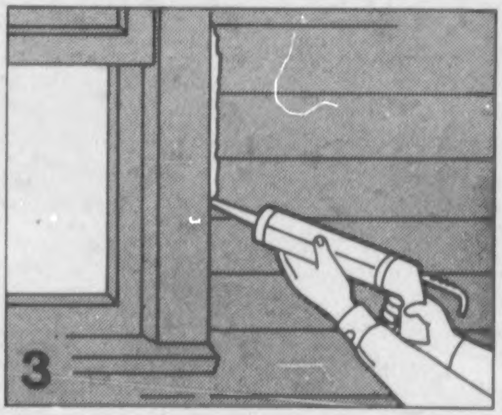
Installation



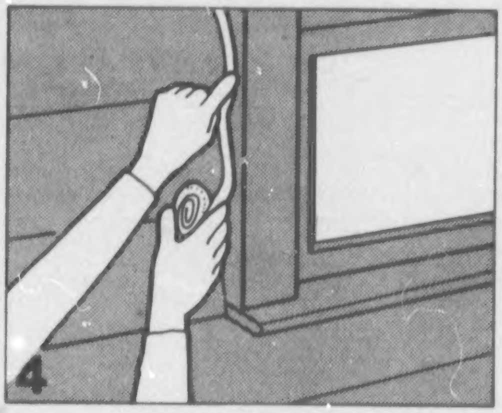
Before applying caulking compound, clean area of paint build-up, dirt, or deteriorated caulk with solvent and putty knife, wirebrush, or screwdriver.



Drawing a good bead of caulk will take a little practice. First attempts may be a bit messy. Make sure the bead overlaps both sides for a tight seal.



A wide bead may be necessary to make sure caulk adheres to both sides.



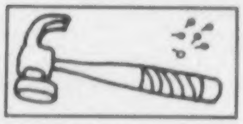
Caulking compound also comes in rope form. Unwind it and force it into cracks with your fingers. You can fill extra long cracks easily this way.

Caution: Lead base caulk is not recommended because it is toxic. Many states prohibit its use.

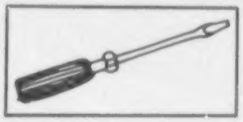
How To Weatherstrip the Windows

Weatherstripping windows can be accomplished by even the inexperienced handyman. A minimum of tools and skills is required.

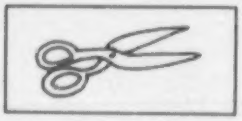
Tools



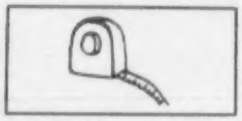
Hammer and nails.



Screwdriver.



Tin snips.



Tape measure.

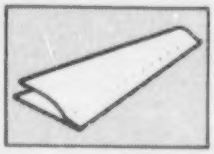
Safety

★ Upper story windows may be a problem. You should be able to do all work from inside, but avoid awkward leaning out of windows when tacking weatherstripping into place.

Materials

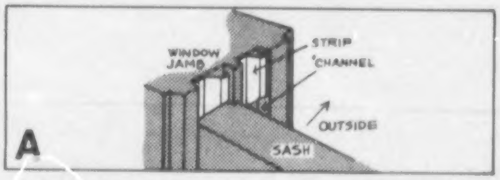
Weatherstripping is purchased either by the running foot or in kit form for each window. In either case you'll have to make a list of your windows, and measure them to find the total length of weatherstripping you'll need. Measure the total distance around the edges of the moving parts of each window type you have. Be sure to allow for waste. If you buy in kit form, be sure the kit is intended for your window type and size.

1. Thin Spring Metal

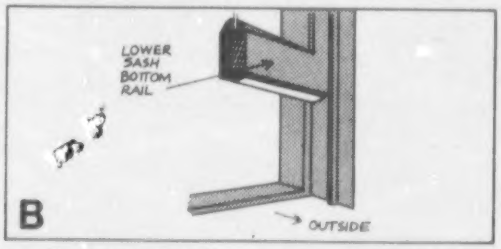


Thin Spring Metal installed in the channel of window so it is virtually invisible. Somewhat difficult to install. Very durable.

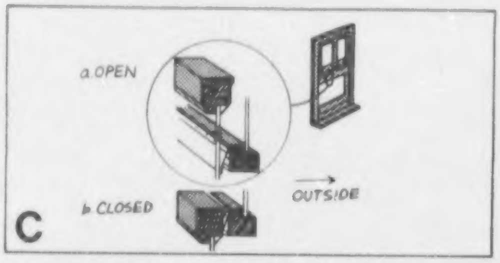
Installation



Install by moving sash to the open position and sliding strip in between the sash and the channel. Tack in place into the casting. Do not cover the pulleys in the upper channels.

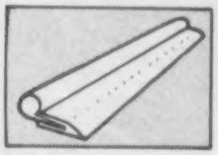


Install strips the full width of the sash on the bottom of the lower sash bottom rail and the top of the upper sash top rail.



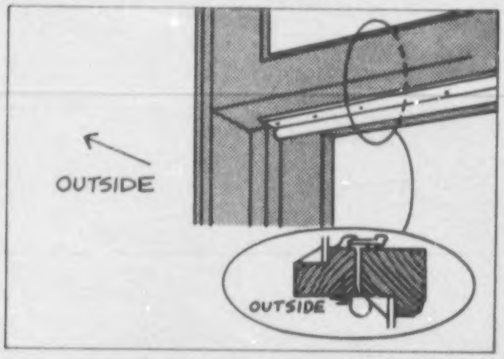
Then attach a strip the full width of the window to the bottom rail of the upper sash. Countersink the nails slightly so they won't catch on the top rail of the lower sash.

2. Rolled Vinyl



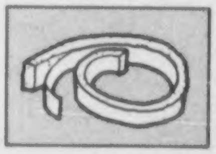
Rolled Vinyl with or without metal backing. Visible when installed. Easy to install. Durable.

Installation



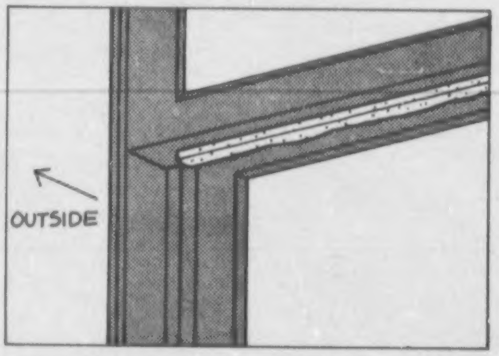
Nail vinyl strips on double-hung windows as shown. A sliding window is much the same and can be treated as a double-hung window turned on its side.

3. Adhesive Backed



Foam Rubber with adhesive backing. Easy to install. Breaks down and wears rather quickly. Not as effective a sealer as metal strips or rolled vinyl. Never use where friction occurs.

Installation



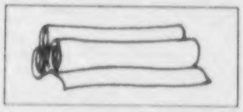
Install adhesive backed foam on all types of windows only where there is no friction. On double-hung windows, this is only on the bottom and top rails. Other types of windows can use foam strips in many more places.

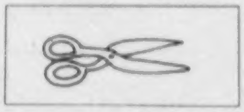
How To Install Storm Windows

1. Plastic Storm Windows

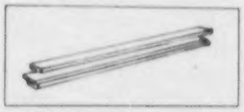
You should know that it is not the storm window itself that keeps the warmth inside in winter and outside in summer. It is actually the dead-air space – at least ¾ inch – between the two windows that saves energy. It used to be that storm windows were suitable only for homes in the northern states during raging winters. Studies have now shown that these "storm" windows are effective in saving energy and providing comfort both in the winter months and in the summer months. You might want to look at several options for improving your windows, going from the most simple and economic to more costly and permanent installations.

Tools


Six mil thick polyethylene plastic in rolls or kits.


Shears to cut and trim plastic.

2" wide masking tape or Hammer and tacks.


¼ × 1¼ wood slats.

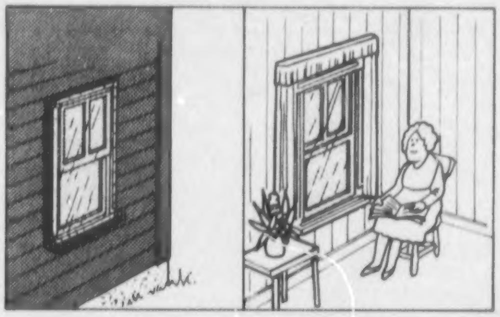
Installation

Measure the width of your larger windows to determine the width of the plastic rolls to buy. Measure the length of your windows to see how many linear feet and, therefore, how many rolls or the proper kit size you need to buy.

Attach to the inside or outside of the frame so that the plastic will block airflow that leaks around the moveable parts of the window. If you attach the plastic to the outside, use the slats and tacks. If you attach it to the inside, masking tape will work.

Inside installation is easier and will provide greater protection to the plastic. Outside installation is more difficult, especially on a two-story house, and the plastic is more likely to be damaged by the elements.

Be sure to install tightly and securely, and remove all excess. Besides looking better, this will make the plastic less susceptible to deterioration.



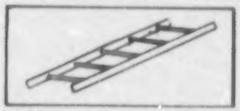
Tack the plastic sheets over the outside of your windows or tape sheets over the inside instead of installing permanent type storm windows.

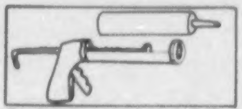
A plastic sheet can be placed over the window to create a partial dead air space. If you want to put off buying storm windows for a year or so, you might consider this as a temporary solution.

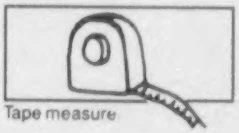
2. Single-Pane Storm Windows

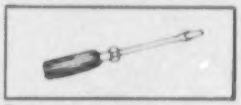
Storm window suppliers will build single-pane storm windows to your measurements. You then install these windows yourself. Another method is to make your own with aluminum, do-it-yourself materials available at most hardware stores.

Tools


Ladder


Caulking gun and cartridges.


Tape measure


Putty knife or large screwdriver.

Advantages & Disadvantages

Single-pane storm windows aren't as expensive as the double-track or triple-track combination windows. The major disadvantage of the single-pane windows is that you can't open them easily after they're installed.

Selection: Judging Quality

Frame Finish

A mill finish (plain aluminum) will oxidize quickly and degrade appearance. Windows with an anodized or baked enamel finish look better.

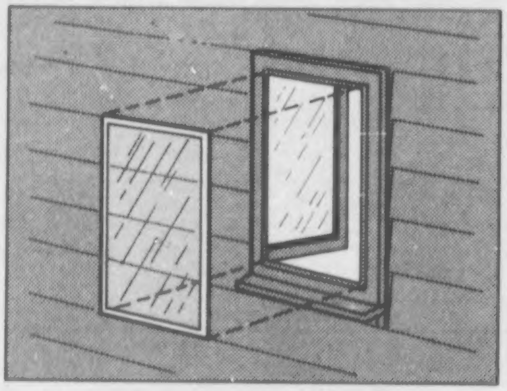
Weatherstripping

The side of the aluminum frame which touches the window frame should have a permanently installed weatherstrip or gasket to seal the crack between the window and the single-pane storm window frames. This helps to prevent the window frame from sweating.

Installation

Determine how you want the windows to sit in the frame. Your measurements will be the outside measurements of the storm window. Be as accurate as possible, then allow ⅛" along each edge for clearance. You'll be responsible for any errors in measurement, so do a good job.

When your windows are delivered, check the actual measurements carefully against your order.



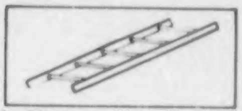
Storm windows should be properly installed and fit tightly to do the most good. To assure a tight fit, permanent storm windows should be sealed to the outer window frame with caulking compound or other sealing material.

How To Install Storm Windows

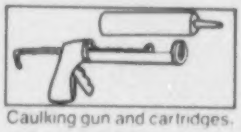
3. Sliding Storm Windows

Sliding storm windows can be opened and closed. They are installed permanently and include a screen which allows you to ventilate the house whenever you wish.

Tools

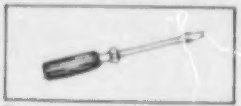


Ladder



Caulking gun and cartridges.

Tape measure



Putty knife or large screwdriver.

Installation

You can save a few dollars by installing the windows yourself. Make sure you get proper instructions from the manufacturer or supplier.

Instead of installing the storm windows yourself, you may want to spend 10 to 15 percent more by having the supplier install your windows for you. The supplier will first measure all the windows where you want storm windows installed. It will take anywhere from several days to a few weeks to make up your order before the supplier returns to install them.

Two very important items should be checked to make sure the installation is properly done: 1. Make sure that both the window sashes and screen sash move smoothly and seal tightly when closed after installation. Poor installation can cause misalignment. 2. Be sure there is a tightly caulked seal around the edge of the storm windows. Leaks can hurt the performance of storm windows a lot.

Selection: Judging Quality

Frame Finish

A mill finish (plain aluminum) will oxidize and reduce the ease of operation. An anodized or baked enamel finish is better looking and will last longer.

Hardware Quality

The quality of locks and catches has a direct effect on durability and is a good indicator of overall construction quality.

Corner Joints

Quality of construction affects the strength and performance of storm windows. Corners are a good place to check construction. They should be strong and air tight. Normally overlapped corner joints are better than mitered. If you can see through the joints, they will leak air.

Sash Tracks and Weatherstripping

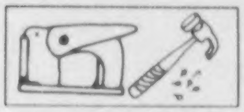
Storm windows are supposed to reduce air leakage around windows. The depth of the metal grooves (sash tracks) at the sides of the window and the weatherstripping quality makes a big difference in how well storm windows can do this. Compare several types before deciding.

Project #4
Door Improvements

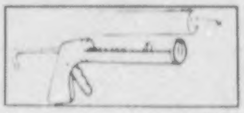
Background

Even in a well-insulated house, a major source of heat loss is from air leaks, particularly around doors. Apart from keeping doors closed as much as possible during heating and cooling periods, you can best insulate the door areas by weather-stripping and caulking. In addition, you may want to look at adding storm doors or a door replacement if your present doors are not suitable for energy conservation.

Tools



Heavy duty staple gun and staples or hammer and tacks

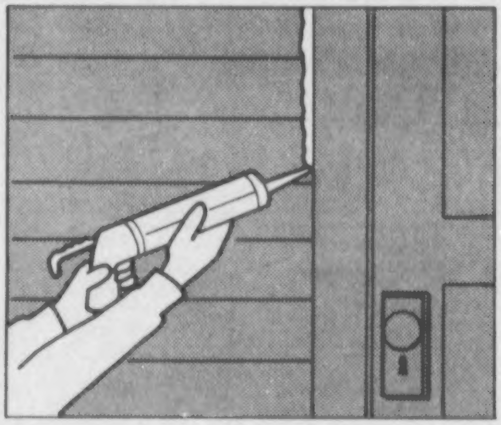


Caulking gun and compound.

Caulking the Doors

Follow the general directions for caulking the windows. Inspect the total door frame. If any old caulking compound has become brittle or has fallen out, replace it with fresh compound. Be sure to fill extra wide cracks like those at door sills with oakum, glass fiber insulation strips, etc. In places where you can't quite fill the gaps, finish the job with caulking compound.

You will need approximately a half cartridge per door, 4 cartridges for the foundation sill, and 2 cartridges for a two story chimney.



Other Areas Which Need To Be Caulked

- ★ At corners formed by siding.
- ★ At sills where the structure meets the foundation.
- ★ Outside water faucets or other special breaks in the outside house surface.
- ★ Where pipes and wires penetrate the ceiling and floors.
- ★ Between porches and main body of the house.
- ★ Where chimney or masonry meets siding.

How To Weatherstrip the Doors

You can weatherstrip your doors even if you're not an experienced handyman. There are several types of weatherstripping for doors, each with its own level of effectiveness, durability and degree of installation difficulty. Select among the given options the one you feel is best for you. *The installations are the same for the two sides and top of a door,* with a different, more durable one for the threshold.

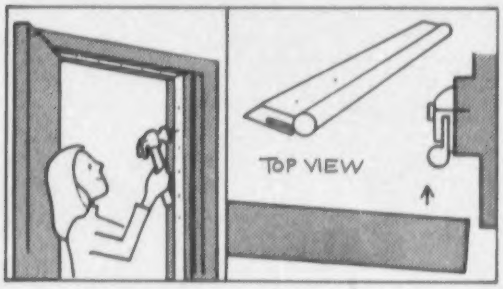
1. Rolled Vinyl With Aluminum Channel Backing

The strip of aluminum is nailed to the edge of the door jamb. The vinyl should fit snugly against the closed door.

Tools

Hammer, nails; Tin snips; Tape measure.

Installation



Nail strip snugly against door on the casing.

Evaluation

Easy to install, visible when installed, durable.

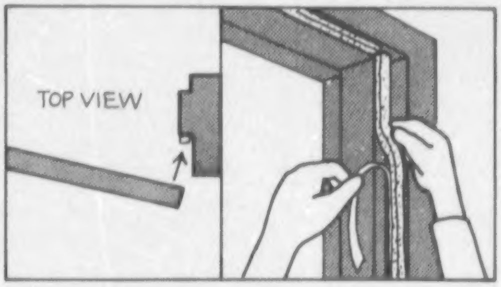
2. Adhesive Backed Foam

The foam strips come in long rolls. Measure the tops and sides of your doors to find out how much you should buy.

Tools

Knife or shears; Tape measure.

Installation



Stick foam to inside face of jamb.

Evaluation

Extremely easy to install, invisible when installed, not very durable, more effective on doors than windows.

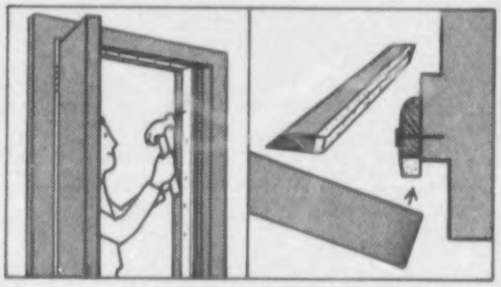
3. Foam Rubber With Wood Backing

These long pieces of wood with foam attached should be positioned so that the foam fits snugly against the closed door.

Tools

Hammer, nails; Hand saw; Tape measure.

Installation



Nail strip so that it fits snugly against the closed door. Space nails 8 to 12 inches apart.

Evaluation

Easy to install, visible when installed, not very durable.

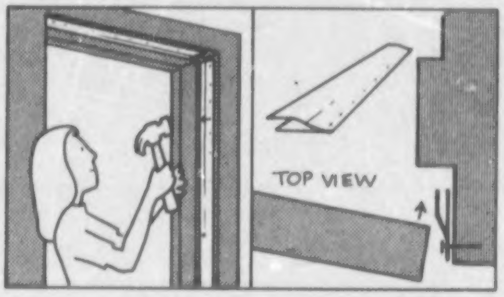
4. Thin Spring Metal

These long strips of metal are fitted to the inside of the door jamb. The outside metal edge should fit tightly against the door when you close it.

Tools

Tin snips; Hammer, nails; Tape measure.

Installation



Cut to length and tack in place. Lift outer edge of strip with screwdriver after tacking, for better seal.

Evaluation

Easy to install, invisible when installed, extremely durable.

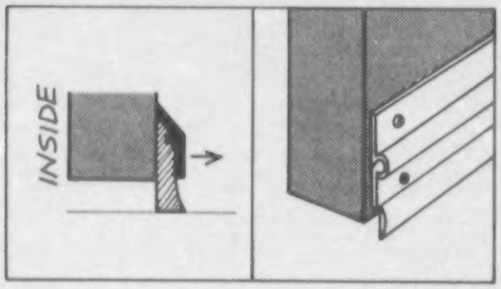
5. Sweeps

These metal strips with rubber or plastic extensions should be fitted to the bottom of the doors to keep air from passing underneath.

Tools

Screwdriver; Hacksaw; Tape measure.

Installation



Cut sweep to fit 1/6 inch in from the edges of the door. Some sweeps are installed on the inside and some outside. Check instructions for your particular type.

Evaluation

Useful for flat threshholds, may drag on carpet or rug.

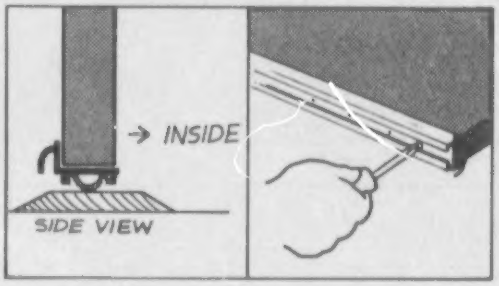
6. Door Shoes

These metal strips are fastened underneath the door. A rubber or plastic gasket fits into the metal slots, thus giving a tight seal against air leakage.

Tools

Screwdriver; Hacksaw; Plane; Tape measure.

Installation



Remove door and trim required amount off bottom. Bottom should have about ⅛" bevel to seal against vinyl. Be sure bevel is cut in right direction for opening.

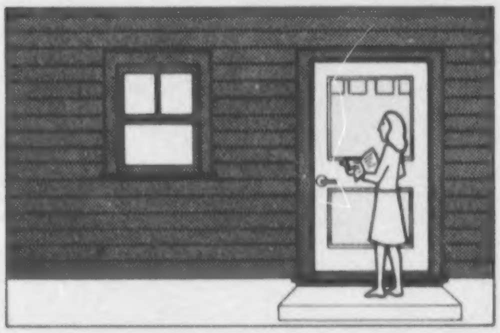
Evaluation

Useful where there is no threshhold or wooden one is worn out, difficult to install, vinyl will wear but replacements are available.

How To Install Storm Doors

1. Combination Storm Doors

Exterior doors, especially hollow-core wood, account for a large portion of heat loss and heat gain. The addition of storm doors is a relatively inexpensive way to correct the problem. A slightly more expensive method of providing more insulation value is to replace exterior wood doors with insulated core doors, often made of metal.



Combination (window and screen) storm doors are designed for installation over exterior doors. They are sold almost everywhere, with or without the cost of installation.

Installation

You can save a few dollars (10 to 15 percent of the purchase price) by installing doors yourself. But you'll need some tools: hammer, drill, screwdriver, and weatherstripping. In most cases, it will be easier to have the supplier install your doors himself.

The supplier will first measure all the doors where you want storm doors installed. It will take anywhere from several days to a few weeks to make up your order before the supplier returns to install the doors. Installation should take less than one-half day.

Before the installer leaves, be sure the doors operate smoothly and close tightly. Check for cracks around the jamb and make sure the seal is as air tight as possible. Also, remove and replace the exchangeable panels (window and screen) to make sure they fit properly and with a weather tight seal.

Selection: Judging Quality

Door Finish

A mill finish (plain aluminum will oxidize and reduce ease of operation. An anodized or baked enamel finish is better looking and longer lasting.

Corner Joints

Quality of construction affects the strength and effectiveness of storm doors. Corners are a good place to check construction. They should be strong and air tight. If you can see through the joints, they will leak air.

Weatherstripping

Storm doors are supposed to reduce air leakage around your doors. Weatherstripping quality makes a big difference in how well storm doors can do this. Compare several types before deciding.

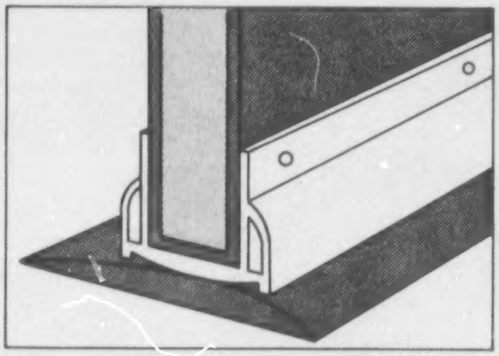
Hardware Quality

The quality of locks, hinges and catches should be evaluated since it can have a direct effect on durability and is a good indicator of overall construction quality.

How To Install Storm Doors

2. Insulated Core Doors

A number of manufacturers offer a new type of door, which usually has a metal jacket and is filled with highly efficient foam-type insulation.



Although they cost about the same, or a little bit more, than solid wood doors with storm doors, they provide about four times as much resistance to heat transfer. Tight-fitting rubber gaskets around the doors reduce drafts and heat loss. These doors are very durable, resist cracking and warping, and are as attractive as wood doors. If you decide to replace a present door with one of these and if you want a glass area in the door, be sure that double-pane glass is specified.

Installation

While these door systems are prehung to make installation easier, they are somewhat difficult to install. Only the more experienced handyman should try this job.

Project #5

Duct Insulation

Background

Generally, you will not need insulation for heating and air-conditioning ducts that are enclosed in already well-insulated portions of your house. But, if the ducts for either your heating or your air-conditioning system run above the ceiling or below the floors, they should be insulated.

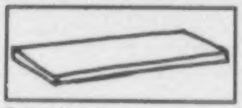
Tools

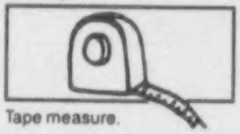
Insulation.

Duct tape.

Heavy duty staple gun.

Knife.


Cuttingboard.


Tape measure.

Safety

- ★ Provide good lighting.
- ★ In the attic, lay boards or plywood sheets down over the tops of the joists or trusses to form a walkway (the ceiling below won't support your weight).
- ★ Be careful of roofing nails protruding through roof sheathing. Wear some kind of protective hat.
- ★ If you use glass fiber or mineral wool, wear gloves and breathing mask, and keep the material wrapped until you're ready to put it in place.

How To Insulate the Ducts

Preparation

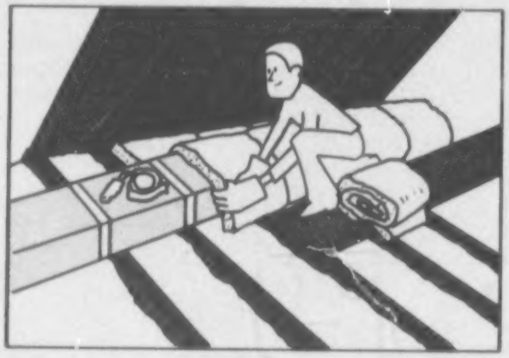
All joints and fittings should be taped before the insulation is added. This will eliminate air leaks and moisture damage to the insulation when you operate the heating or cooling system.

Installation

Determine where the ducts are located. They may be furred down into the conditioned space or may be in exposed areas such as the attic or under the floor.

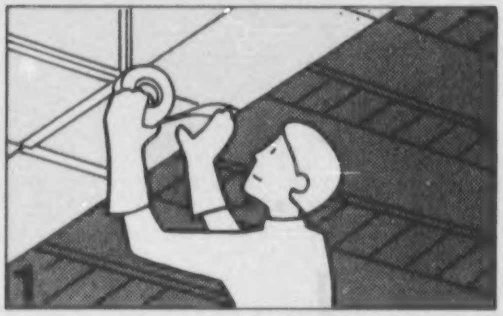
The ducts that are furred down generally need no additional insulation. These should be installed in an area which is sealed air tight from the attic space.

If the ducts are in the attic or beneath the floor then the following directions should apply.



How To Insulate the Ducts

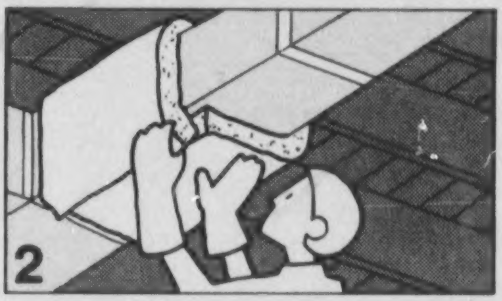
You should wrap all ducts with insulating blankets. At least two inches of insulation is desirable. If the supplier does not have the two-inch foil-backed duct insulation, then you can use a combination of 1" unfaced (no foil) and 1" foil or vinyl backed duct insulation.



Tape all duct joints and seams before you insulate the ducts to prevent any air leakage.

Cut the insulation long enough to have a two-inch overlap of vapor barrier. You need this overlap to staple the insulation. Place the vapor barrier (foil or vinyl side) away from the ducts.

If your ducts already have some insulation, check to see if any moisture has collected in it. If so, it would be best to replace it with new insulation. But, if the old insulation is still in good condition, and you need to add more to get the desired two-inch protection, be sure you make a number of slashes at six inch intervals through the old foil vapor barrier before you add the new foil-backed insulation.



Pull the insulation snug, *not tight*, to reduce air pockets. If you pull the insulation tight, you will reduce its insulating value.

After you have wrapped the ducts, tape the edges of the various pieces of insulation. And then staple the tape so it won't come loose. If you accidentally put a hole in the vapor barrier, seal it with insulation tape. This foil vapor barrier will keep moist air from reaching the cool ducts in summer and will protect the insulation from moisture damage.

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. Human Comfort and Energy Conservation may be offered by itself or as part of a sequence of three modules in the following order:

Order	Module	Title of Module
1	9	Human Comfort and Energy Conservation
2	8	Building Construction vs Energy Consumption
3	10	Heating, Ventilating, and Air Conditioning Conservation Opportunities

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

INTRODUCTION:

This block of instruction is an introductory study of human comfort variables such as air temperature, humidity, air movement, activity, age, geographical location, and dress. There will be discussion of energy conservation and ways of controlling energy use while still maintaining "productive" human comfort conditions.

COURSE DESCRIPTION

The student will be introduced to an overview of energy use for human comfort and the opportunities for conserving fuel and power use as savings in operating costs. The nature of creature comfort and temperature control will constitute the content of this module.

OBJECTIVE:

The objective of this module is to train secondary and post-secondary individuals in the recognition, implementation, and utilization of energy conservation for creature comfort and thermal control.

GOAL STATEMENT:

On completion of Unit III, the student will be able to explain why thermal controls in the home and place of work should be set in accordance to the occupancy and duration of stay. Additionally, the student will learn why activity and clothing are important in achieving heat balance and comfort.

READING GRADE LEVELS:

Lecture: 17
Lab : 12

SUGGESTED TEACHING TIMES:

Secondary : 3-5 hours
Postsecondary: 1 1/2-3 hours

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

Unit I. The Nature of Thermal Comfort in Humans

- A. Thermal Energy in Humans
- B. Effects of Heat and Cold
- C. Survival and Comfort
- D. Clothing, Food, Water, and Health

Unit II. How Natural Climates and Artificial Environments are Defined

- A. Characteristics of Hot and Cold Air
- B. Air Movement and Humidity
- C. Natural Outdoor Conditions vs. Season and Geography
- D. How Human Comfort Zones are Measured

Unit III. Controlling Buildings for Thermal Comfort

- A. Occupancy and Duration
- B. Activity and Clothing
- C. Workplaces vs. Homes
- D. Energy-Saving Options

MODULE IX

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TERMINOLOGY

Acclimation--the process of result of adapting to a new temperature, altitude, climate, environment, or situation.

Air velocity--speed at which air moves with respect to a designated reference point (it has both a speed and a direction.)

Anemometer--an instrument for measuring and indicating the force or speed of the wind.

Black-bulb (globe) thermometer--a thermometer whose sensitive element has been made to approximate a blackbody by covering it with lampblack used for globular measurements.

British Thermal Unit (Btu)--the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Calorie--the amount of heat required at a pressure of one atmosphere to raise the temperature of one gram of water one degree centigrade.

Carbohydrate--any of various neutral compounds of carbon, hydrogen, and oxygen (as sugars, starches, and celluloses) most of which are formed by green plants and which constitute a major class of animal foods.

Climatology--the science that deals with the course or condition of the weather at a given place over a period of years as exhibited by temperature, wind velocity, and precipitation.

"Clo"--the unit of measurement for thermal insulation values of clothing.

Cold-blooded--having a body temperature not internally regulated but approximately that of the environment, dependent on external climatic factors.

Comfort zone--the ranges of indoor temperature, humidity and air movement under which most persons enjoy mental and physical well-being.

Conduction--the transfer of heat through direct contact between two or more conductors of heat which are at different temperatures.

Convection--the transfer of heat by the automatic circulation of a fluid due to a temperature gradient.

Dry bulb temperature--the actual air temperature, or that of dry air as measured by an ordinary thermometer not dependent upon atmosphere humidity.

Humidity--a measure of the amount of water vapor in the atmosphere or air. (Usually given as "relative humidity", the percent of maximum moisture capacity from the dry bulb temperature.

Insulation--material used to separate conducting bodies by means of a method that is less conductive in order to reduce the transfer of electricity, heat, or sound energy.

Isotherm--a line on a map or chart of the earth's surface connecting points having the same temperature at a given time or the same mean temperature for a given period.

Kilocalorie--the amount of heat required to raise the temperature of one kilogram of water one degree centigrade: 1000 gram calories or 3.968 Btu.

Kilogram--the basis metric unit of mass and weight equal to the mass of a platinum-iridium cylinder kept at the International Bureau of Weights and Measures near Paris and nearly equal to 1000 cubic centimeters of water at the temperature of its maximum density.

Non-acclimatized--opposite of acclimatized. (See acclimatization).

Protein--any of numerous naturally occurring, extremely complex combinations of amino acids that contain the elements carbon, hydrogen, nitrogen, and oxygen; usually sulfur; and occasionally other elements (as phosphorus or iron); are essential constituents of all living cells, and are synthesized from raw materials by plants but assimilated as separate amino acids by animals.

Psychrometer--a device comprising two thermometers: one a dry bulb for measuring a temperature, and the other a wet, or wick-covered bulb, for determining the moisture content, or relative humidity, of air or other gases.

Radiant heat--energy transmitted by radiation. The amount of energy radiated by any body is proportional to the fourth power of the absolute temperature.

Relative humidity--the ratio of the amount of water vapor actually present in the air to the greatest amount possible at the same temperature.

Solar radiation--the complete spectrum of electromagnetic radiation and particles emitted by the sun.

Sub-tropical zone--of, relating to, or being the regions bordering on the tropical zone. This corresponds to the general region which is located on latitudes of 20° to 30° N and S of the equator.

Temperate zone--the area or region between the tropic of Cancer and the arctic circle, or between the tropic of Capricorn and the antarctic circle. Dependent also on altitude near the tropics located next in increasing latitude to the sub-tropical zones.

Thermal energy--the mean energy a particle of air has as a function of ambient temperature based on the ideal gas law.

Thermograph--an instrument that senses, measures, and records the temperature of the atmosphere.

Tropic zone--the region located on both sides of the equator below the two tropics in latitude, or roughly the belt from 20° N to 20° S latitude.

Wet-bulb temperature--the air temperature as measured by a thermometer having the bulb covered with a cloth, usually muslin or cambric, saturated with water. Determines the relative humidity of the air.

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MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. All forms of life contain thermal energy.

   a. true b. false

2. Heat and thermal energy are the same.

   a. true b. false

3. The Btu is a unit used to measure:

   a. the heat of a body
   b. the total thermal heat of a body
   c. a and b
   d. none of the above

4. Humans acquire thermal energy from:

   a. water
   b. minerals
   c. foods
   d. all of the above

5. Age plays no part in one's caloric needs.

   a. true b. false

6. In humans, excess calories will be converted into:

   a. muscle tissue
   b. fat tissue
   c. a and b
   d. none of the above

7. Heat is due to:

   a. molecular collisions
   b. transfer of ions
   c. exchange of electrons

8. The rate of air movement is an important factor affecting the rise or fall of body temperature.

   a. true b. false

9. The body can compensate for environmental changes.

   a. true b. false

10. There are units that designate the insulation value of clothing.

    a. true b. false

11. All of the cooling of the body is brought about through the evaporation of water from your skin.

    a. true b. false

12. Dry bulb temperature (T_{DB}) and Wet bulb temperature (T_{WB}) are used in measuring annual precipitation.

    a. true b. false

13. Air above your skin acts as an insulator.

    a. true b. false

14. The Globe thermometer measures relative humidity.

    a. true b. false

15. Relative humidity is important to human comfort.

    a. true b. false

16. In controlling the temperature of a building, it is important to know that building's rate of occupancy.

    a. true b. false

17. Excessive body heat can be reduced by:

    a. increasing evaporative cooling
    b. increasing air temperature
    c. increasing "clo" value of garments
    d. all of the above

18. One connot have temperature control in the home and still save energy.

    a. true b. false

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

ANSWERS TO PRETEST

1. a. true
2. b. false
3. b. the total thermal heat of a body
4. c. foods
5. b. false
6. b. fat tissue
7. a. molecular collisions
8. a. true
9. a. true
10. a. true
11. a. true
12. b. false
13. a. true
14. b. false
15. a. true
16. a. true
17. a. increasing evaporative cooling
18. b. false

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

UNIT I

THE NATURE OF THERMAL COMFORT IN HUMANS

GOAL STATEMENT

Unit I is one of three units within the module Human Comfort and Energy Conservation. In this unit, the student will be introduced to basic facts concerning thermal energy derived from food and the conservation of thermal energy by the human body. Heat losses and heat will also be considered as they are related to survival, comfort, clothing, food and water intake, and health.

UNIT OBJECTIVES

Upon completion of this unit, the student will be able to:

1. Differentiate between thermal energy and heat.
2. Describe what causes thermal energy.
3. Explain how the total thermal energy of a body is expressed.
4. Give the meaning of a Btu.
5. Give the meaning of a kilocalorie.
6. Explain where human beings are able to acquire thermal energy.
7. List eight factors that may help to determine your caloric needs.
8. Explain what happens to the excess calories we consume.
9. List four important factors that affect the rise or fall of the body temperature.
10. Explain how the body may compensate for heat loss or heat gain.
11. Give the unit used to measure the insulation value of clothing.
12. Tell what kind of foods release thermal energy the fastest.
13. Explain why water is important to the cooling of the human body.

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

UNIT I

THE NATURE OF THERMAL COMFORT IN HUMANS

GOAL STATEMENT

Upon completion of this module, the student will be able to readily relate thermal in humans to:

a. Temperature measurements,

b. Individual differences,

c. Seasonal and geographic differences, and

d. The human comfort zone.

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

UNIT I

THERMAL ENERGY IN HUMANS

LECTURE

a. Thermal Energy in Humans

Like all forms of matter--living or non-living--human beings contain internal energy called thermal energy. Before you go any farther, however, you need to know the difference between thermal energy and heat. A body (e.g.,human being, automobile, rock, bar of gold, ice) stores or contains thermal energy, not heat. Heat is thermal energy that is transferred to, from, or within a body. In Physics in Perspective, Eugene Hecht compares heat to wind and thermal energy to air. As Hecht points out, moving air is called wind. However, when the air stops moving, no longer is there wind. However, molecules of gases are still making up air. It is the wind, explains Hecht, that blows up a ballon, but air is what is stored in the balloon.

What produces thermal energy? The molecules composing all matter (living matter, sand, snow or water) are in constant motion. As collisions occur between the molecules, thermal energy is produced. With other factors remaining constant, an increase in the rate of molecular collisions increases the thermal energy contained within an object. Conversely, if there is a lower rate of molecular

ACTIVITIES

Measuring Body Temperature Ranges

a. Measure your body temperature with a clinical thermometer. It will be somewhere in the range of 97°--100°F (36.1-37.8°C) unless one of the special conditions which are listed on the body temperature chart applies. (Figure 1.1) A common average temperature, when measured in the human mouth, is 98.6°F. Record the lowest average, and highest mouth temperatures in your class.

collisions within an object (of the same size and same material), then there will be less thermal energy contained by that object as compared with the former object.

As pointed out above, human beings, like other forms of matter contain thermal energy. However, unlike non-living forms of matter, human beings must, if they are to live and be active, possess a relative constant amount of thermal energy and body temperature of humans must, therefore, remain within a rather narrow range. Most individuals will suffer convulsions if their body temperature rises to 106°F-107°F. However, it is important to realize that even in a "perfectly normal" individual the temperature is not the same in all parts of the body. The temperature of the brain and arterial blood may be kept at 98.6°F, while the temperature of the arms and legs may be considerably lower.

Although the temperature concept is not clear, it must be noted that the temperature of a body is not a measure of the amount of thermal energy that body contains. Rather, temperature is a measure of the intensity of its heat. Since the temperature of a body is determined by the average velocity of molecular collisions, obviously it is possible for one body to be hotter than another body yet contain less thermal energy. Let's examine an example: A quart of boiling water is certainly hotter than a No. 3 tub of warm water. However, the quart of boiling water contains less thermal energy than the tub of warm water because it contains fewer molecules that are colliding. Therefore, temperature is a measurement of the intensity of the heat of a body.

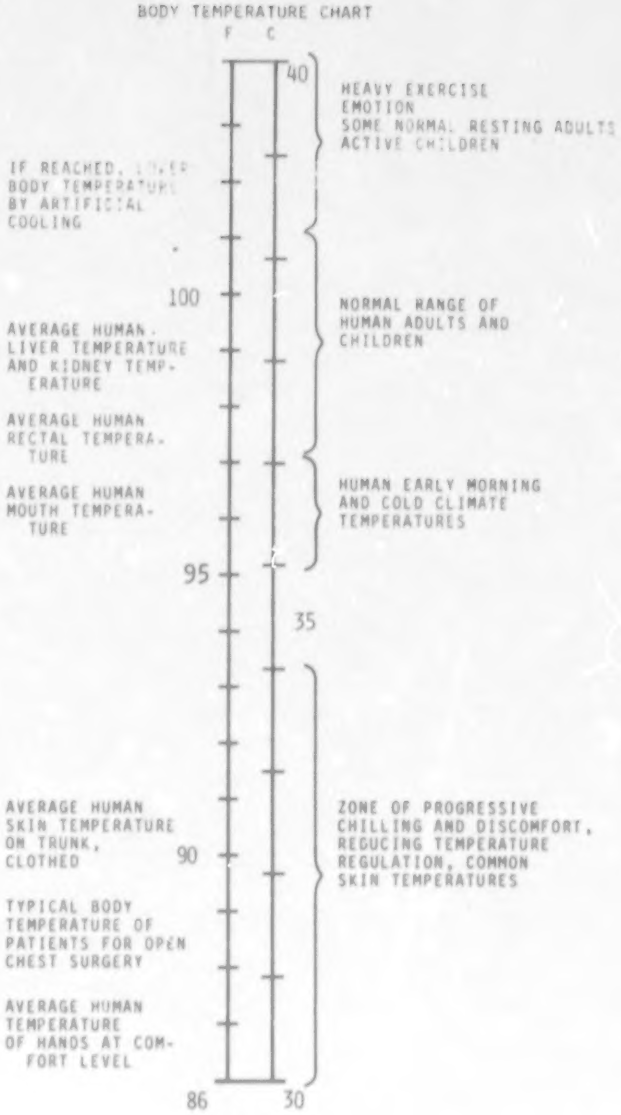


FIGURE 1.1

Temperature may be expressed in degrees Centigrade or Fahrenheit. The total thermal energy contained by a body is, however, expressed by a different unit will be discussed later on in this module.

The total heat content of the body can be determined by the net difference between the heat produced and the heat lost. When speaking of a constant body temperature, it is necessary to realize that heat production must equal the amount of heat lost. Additionally, in the human body heat production and heat loss are governed by various physiological mechanisms.

Since heat is lost from the surface of the body by radiation, conduction, convection, and water evaporation, in time its thermal energy content would be dramatically reduced if there were not some provision for providing the body with needed thermal energy. How does the human body get needed thermal energy?--from the food that is consumed. However, it should be noted that foods, in addition to providing the energy that is necessary for the proper functioning of the body, provide the structural components out of which the body is made. In this study, an examination of the energy supplied by food will be made.

First, how is this energy supplied to the body measured? It is measured in units called kilocalories (Metric system) or British thermal units (Btu-English system). One Btu is the amount of heat needed to change one pound of water by 1°F. One kilocalorie equals approximately one Btu. However, kilocalorie must also be defined since both of these units are in common use. One kilocalorie is the amount of heat required to raise 1 Kg. of water 1°C. However, when referring to food, the kilocalorie is the more commonly used of the two units. Additionally, a kilocalorie is usually referred to as simply a calorie.

The energy that is contained within the chemical bonds of the food consumed will then be used for such energy-requiring activities as muscle contraction, blood circulation, neural activity, and maintenance of body temperature. Food consumed and not used as structural components of the body, or converted into energy to maintain the body's vital activities and temperature, will be converted into fat and stored in a special tissue called adipose tissue (fat tissue) that is usually found under the skin.

Individual caloric requirements will vary according to age, sex, height, weight, body surface area, emotional state, environmental temperature, circulating levels of certain hormones, and other factors.

UNIT 1:

b. Effects of Heat and Cold

Any part of the skin that is not covered by clothing or hair is called "exposed skin" because it is open to the surrounding environment.

Exposed skin is sensitive to changes in temperature, radiant energy, and wind velocity. If the surrounding air is warmer than the skin, thermal energy will move from the air through the skin to the body core. Should this be allowed to continue, then ultimately the temperature of the deeper portions of the body will begin to rise.

Differences in Skin Temperature

b. To show that skin temperature changes, select two students with characteristically different skin pinkness (flushing) at the beginning of class, and show by touch that skin flush is accomplished by warmth, and skin turning pale is indicative of a cool surface temperature. Have individual students compare forehead, nape of neck, back of hand, palm of hand and foot temperature. In many cases, there will be substantial differences in skin temperature and skin color.

Four important factors affect the rise or fall of body temperature:

(1) the difference between the temperature of the air and the temperature of the skin;

(2) the rate of air movement;

(3) the relative humidity of the air; and,

(4) the difference between the temperature of the surface of the skin and the temperature of surrounding walls and other surfaces.

It is important to note, however, that the body possesses adaptive mechanisms which prevent large rises or falls in body temperature when the temperature of the environment changes. These adaptive mechanisms may be of a behavioral or a reflex nature. Examples of reflex and behavioral adjustments to external environmental temperatures are given in Figures 1.2 and 1.3.
However, if the surrounding air is colder than the skin, then thermal energy will move from the body core through the skin and to the air. If this condition is permitted to continue, the body temperature will fall.

COMPENSATORY RESPONSES

	THERMAL SURROUNDINGS	HEAT PRODUCTION CHANGE
1	COLD AIR WINTER SEASON COLD CLIMATES	INCREASED PHYSICAL ACTIVITY INCREASED FOOD INTAKE DECREASED FLUID INTAKE AND SWEATING
2	HOT AIR SUMMER SEASON HOT CLIMATE	DECREASED PHYSICAL ACTIVITY DECREASED FOOD INTAKE INCREASED FLUID INTAKE AND SWEATING

COMPENSATION IS OVER A PERIOD OF TIME AND IS PARTLY VOLUNTARY.

FIGURE 1.2

Effects of Moving Air

In order to show the effects of moving air, have the students blow gently on the back of their hands or pass in front of a moving fan to sense coolness. Use a vane gauge aerometer to show that the higher the air movement the cooler the sensation of exposed skin.

Effects of Humidity

To show the effects of humidity in the air and on the skin, moisten skin. Again, blow on the hands or move in front of a fan. Using a sling psychrometer, show that the air is usually humid, or has a higher relative humidity early in the day and while near trees/vegtation/water than late in the day, indoors, away from vegetation and water. Which situations feel coolest?

Effects of Radiation of Temperature

To show the effects of surface temperatures and radiation, use one or more black globe thermometers mounted (a) in sunshine; (b) near hot surfaces, such as hot walls, stoves, running motors; (c) near cool surfaces, such as cold windows, cool floors or walls, and outside a refrigerator door. Can the skin detect heat flow towards or away from a surface (a) by touching the surface, and (b) by holding your hand near the surface but without touching it. (NOTE: A black globe thermometer measures the effects of radiant heat entering or leaving a matt-black copper globe, usually 5-6 inches in diameter.)

ADJUSTMENTS TO SKIN HEAT LOSS

	THERMAL SURROUNDINGS	SKIN-BLOOD FLOW CHARGE
1	COLD AIR LOW THERMOSTAT SETPOINT LOW SURFACE TEMPERATURES	BLANCHES SKIN, REDUCED BLOOD FLOW, LIMITED SWEATING, SHIVERING; INCREASED HEAT PRODUCTION
2	HOT AIR HIGH THERMOSTAT SETPOINT HIGH SURFACE TEMPERATURES	PINK SKIN, INCREASED BLOOD FLOW SWEAT RATE RAISES; INCREASED HEAT LOSS; AREA OF MOIST SKIN INCREASED

ADJUSTMENTS ARE RAPID AND CONTROLLED BY NERVOUS REFLEX.

FIGURE 1.3

To show that skin appearance and sweat rate are different in cold surroundings as opposed to hot surroundings, class members should visit and observe persons in cold workplaces as well as hot workplaces, e.g., nearest factory, kitchen, walk-in refrigerator, or cold storage area. Describe and record the observations and personal sensations of skin coolness or warmth.

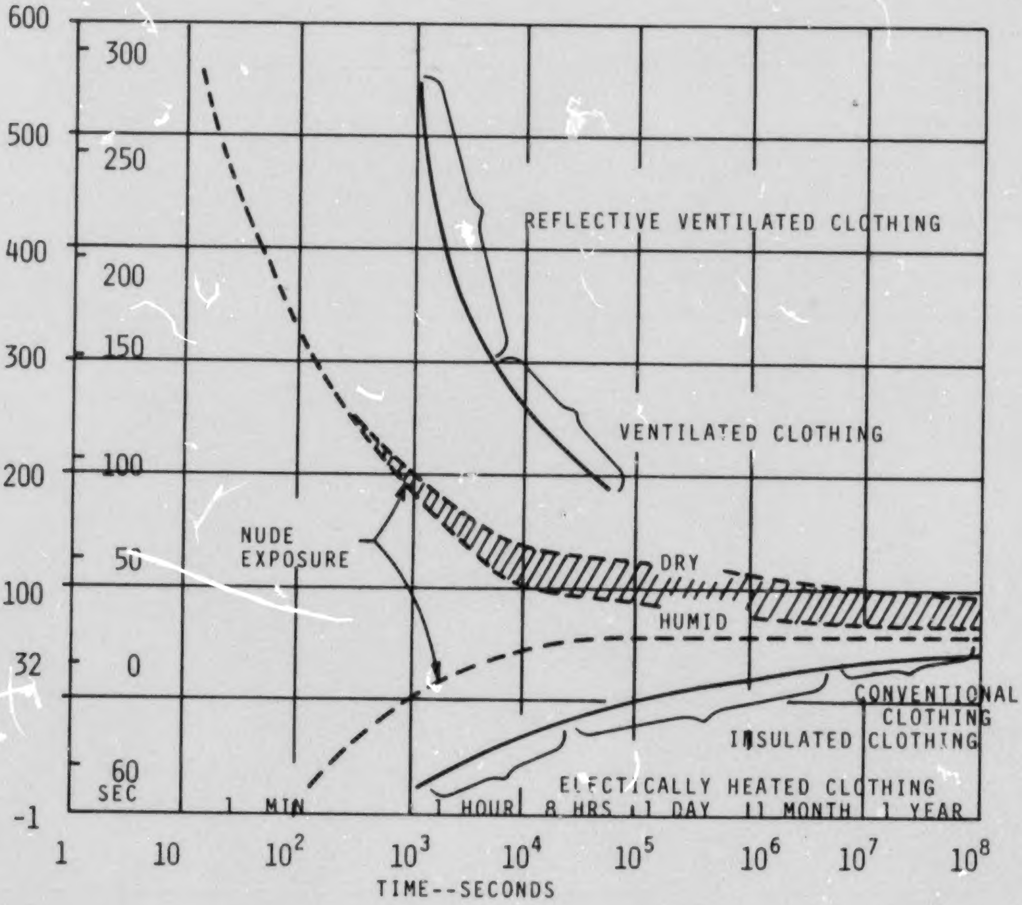
c. Survival and Comfort

For short periods, human beings can withstand extreme temperatures. However, the more extreme the temperature, the shorter the duration. Additionally, in very high or very low temperatures, the human body requires some kind of protection. (For example, people working in such extreme environments as near a blast furnace or in a meat locker must have special clothing.)

Study Figure 1.4 and discuss the relation between tolerance time and temperature.

TEMPERATURE-TIME SURVIVAL CHART

THE MAN-MADE ENVIRONMENT-TEMPERATURES FOR HUMAN SURVIVAL IN AIR



SOURCE: JOHN FLETCHER, ENVIRONMENT, ENERGY AND SOCIETY, 1973.

FIGURE 1.4

In Figure 1.4, note that with special protective clothing a person can withstand a temperature of -40°F (-40°C) to +320°F (+160°C) for a period of one hour. Also note that without clothing and under hot, humid conditions, an individual can only withstand temperatures between +40°F (+5°C) to 170°F (+77°C) and +40°F (+5°C) to -130°F (-90°C).

What are the potential causes of death when one is exposed to either extreme heat or extreme cold? Frostbite and deep body chilling result from extreme cold, while heat prostration and heat stroke result from extreme heat.

Temperature comfort is, of course, necessary if a worker is to achieve optimum production. Therefore, when worker efficiency is being considered, it is of the upmost importance to determine the usual temperature under which work is done.

The time of day when individuals are at work is very important to consider. For example, 8-hour shift work is usually from 8 a.m. to 4 p.m., 4 p.m. to 12 midnight, and 12 midnight to 8 a.m. In which of the three shift periods would the lowest temperature be expected? The midnight to 8 a.m. shift should be the coolest because these are the hours of darkness. (Would this be true of shift work in your area?) Go to the local newspaper and check the temperatures during a 24-hour period. Temperatures during the various times of a 24-hour period are usually recorded by a thermograph. A thermograph is a recording thermometer which charts temperature readings on a stripchart drum or a circular paper chart.

c. A working day is usually regarded as 8 hours. Using the graduated scale on the guide, request that each student note feelings at the temperature of the classroom or laboratory, remembering the duration of the class is only 1-2 hours. How would the student react if the temperature were:

(1) 60°F (16°C) for 8 hours (Note: this temperature is close to the lower limit of exposed survival).

(2) 100°F (38°C) for 8 hours (Note: this temperature is close to the upper limit of exposed survival).

(3) 60°F (16°C) for 1 hour
(4) 100°F (38°C) for 1 hour
(5) 70°F (21°C) for 1 year

(Figure 1.5 is a "Comfort Score Guide")

COMFORT SCORE GUIDE

THE DESCRIPTIONS BELOW REPRESENT THE GRADUATING SCALE FOR INDICATING DEGREES OF COMFORT.

1. COLD
2. COOL
3. SLIGHTLY COOL
4. COMFORTABLE
5. SLIGHTY WARM
6. WARM
7. HOT

FIGURE 1.5

Why is this? (Hint: See the extreme right hand side of the Temperature-Time Survival Chart [Figure 1.4] which indicates a one-year duration.)

Directions: Mount a thermograph close to the largest available classroom/ laboratory window, and another near a suitable secure location just outside (e.g., a fire escape or roof).

Just as temperature is important to worker productivity, it also is important to individuals confined to their homes. For example, babies, the ill, or the handicapped must remain in a relatively narrow temperature zone if they are to survive. This is why newborn babies are often placed in incubators. Also, this is why very old people are often very uncomfortable during certain times in a 24-hour period.

UNIT 1:

d. Clothing, Food, Water, and Health

One important factor human beings can use in order to have some control over their comfort in relation to temperature, is in clothing worn. Clothing, of course, provides thermal insulation and also prevents hot or cold air from moving over the body.

Just as there are units of measurement concerning the effectiveness of the insulation used in homes, certain units of measurements can be used to determine the thermal insulation value of clothing. This unit is called the "clo". The greater the "clo" value, the greater the thermal insulation quality of the garment. On the other hand, a low "clo" value indicates little thermal insulation quality. For example, single layer, light, woven fabrics allow considerable heat and moisture exchange through the cloth. Therefore, the overall thermal insulation value of that.fabric, as measured in "clo" units, would be a relatively low numerical value. The value might be something of the order of 0.15 to 0.40 "clo" units. However, if several layers of the fabric are worn, heat exchan exchge and moisture evaporation are reduced, and the insulation value would probably be 0.40 to 0.80 "clo" units.

Record yesterday's readings and compare them. (1) Were there major temperature differences between day and night outside? (2) Did the indoor temperature record show any form of cyclical change? (3) Were the hours of high and low temperature similar inside and outside the classroom/laboratory windows?

ature. The process is known as "acclimatization" or "adaptation." Usually, acclimatization requires several days or weeks. It should be obvious that the heat-acclimatized person in warm surroundings will feel more comfortable than the non-acclimatized individual. On the other hand, the cold acclimatized person will feel more comfortable in cold surroundings than the non-acclimatized person. Therefore, a consideration of acclimatization is just as important as the "clo" value of clothing when one is concerned with the comfort of human beings. For example, two people with the same kind of clothing but with different acclimatization backgrounds may note different degrees of comfort even if they work at adjacent desks.

While the "clo" value of materials is extremely important, other qualities of materials should be considered. For example, wool maintains its "clo" value even when wet. Therefore, this ability to maintain "clo" value makes it an excellent choice for use in cold, wet climates.

Food, in releasing energy in the form of heat, is to the human body what oil is to a furnace. Depending upon the type and quality of food ingested, four to six hours are required for its digestion and accompanying release of thermal energy.

Carbohydrates (candies, bread, sugar) release their thermal energy quickly. Fatty foods (fatty meats, dressings, fried foods), however, release greater quanities of thermal energy over a longer period. Proteins also release thermal energy at a slower rate than carbohydrates.

The yardstick used to measure the amount of thermal energy a food yields is the calorie. A part of this energy released from the food consumed is used to maintain the metabolic processes of the body. The metabolic processes, and therefore energy consumption, vary according to such factors as sex, weight, age, health, and health.

For example, if two people are of the same age, sex, and size, but one is engaged in more physical exercise than the other, then the more active person will expend more energy in carrying out those activities.

Obviously, different types of fabrics and clothing have varying "clo" values. Winter clothing, for example, that is lined or fur-insulated usually has a "clo" value between 0-8 and 2.0 "clos". It is interesting to note that even the very best quality of arctic winter clothing can insulate no better that 25 times lightweight clothing. These values would range between 2.0 and 4.0 "clos".

During recent years the average indoor clothing "clo" value of men and women's garments has changed from an average of 0.9 "clo" units to those shown in Figure 1.6.

The "clo" values of individual garments range from 0.01 to 0.03 for pantihose and socks to 0.49 to 0.63 for a light jacket or a warm dress.

By adopting different cold-weather and hot-weather styles of dress, people are able to vary the "clo" value of their clothing as well as the amount of exposed body surface. By repeated exposure to the changing heat of summer or cold of winter, individuals become seasonally or residentially accustomed to the climate and temper-

Have students keep a list of all food consumed during one week. Using the calorie table at Figure 1.9., calculate the daily calorie intake. Break down each meal into the number of carbohydrates, proteins, and fats consumed. Are there any differences in the quantity or type of food consumed on days where heavy physical activity occurs versus a day of less strenuous activity?

Under what conditions would each of the material qualities be considerations when purchasing?

Review your school menu or food vending machines. What items are sold? Which classes of food (e.g., snacks) would persons who felt uncomfortably cool consume. Uncomfortably warm? On starting a mid-shift lunch break after doing four hours of hard work? Is it important to expand energy to change the temperature of a snack? Does a hot beverage produce sweating which in turn lowers or cools body temperature?

CLOTHING ENSEMBLE CLO VALUES

	AN AVERAGE OF 12 SEDENTARY INDOOR CLOTHING ENSEMBLES.	LIGHT, SUMMER, SUB TOPICAL.	HEAVY, WINTER, NORTHERN USA.
MEN	0.76	0.38	1.18
WOMEN	0.74	0.27	1.20

(ALL VALUES IN CLO UNITS)

SOURCE: JOHN FLETCHER, ENVIRONMENT, ENERGY AND SOCIETY, 1973

FIGURE 1.6

To show that considerable variation exists in clothing worn, have class members inventory the garments they are presently wearing. What changes in the inventory would they expect on (a) very hot days, or (b) very cold days? Using the Table on Individual Garments in Figure 1.7, assign "clo" values to each garment worn. Add and compare total "clo" units per person. How do they compare? Discuss the reasons for differences between "clo" units of various class members. (e.g., a person with a slight cold or fever will have a clothing "clo" value total higher than a person who has just come from gym class after running and playing). Discuss seasonal change of "clo" values.

Discuss the various qualities of different materials listed in Figure 1.8. What types of material would one consider for various activities, such as:

a. tennis outdoors in summer?

b. tennis outdoors in winter?

c. watching a parade on a sunny but cold day in January?

d. watching a parade on a hot July 4th?

e. hiking in May?

f. hiking in December?

If the diet contains more calories than the body requires for its metabolic function, the unused calories will be converted into fat and stored as fatty tissue.

Water accounts for approximately 70% of the body by weight. Therefore, it is not surprising that life cannot exist without sufficient water intake. As would be expected, in warm climates and during hard work thirst develops more frequently than in cool climates and during sedetary work. Why? Because an increase in temperature and exercise speeds up the loss of water from the body by evaporation. The evaporation is extremely important because this cools the body. For each gram of water evaporated, the cooling effect is 640 calories. However, not all of the cooling of the body is brought about by the evaporation of water from the skin. It has been estimated that 55% of the cooling of the body occurs through the loss of moisture from the lungs.

Good health can be maintained during a wide range of environmental temperatures provided proper clothing and an adequate diet are provided. However, an individual's health may be adversely affected by a sudden onset of cold weather or

Discuss Figure 1.9 in relation to individual daily calorie intake and daily activities. Are the two in balance? If not, do you have a tendency to intake more calories than you require? Discuss solutions to this condition.

Have students keep a listing of food consumed during one week. Using the calorie table at Figure 1.9. Calculate the daily calorie intake. Break down each meal into the number of carbohydrates, proteins, and fats consumed. Are there any differences in the quantity or type of food consumed on days where heavy physical activity occurs versus a day of less strenuous activity?

prolonged cold, wet periods, and heat waves. During such periods, excessive deaths usually result from a variety of respiratory diseases such as influenza, during times of cold, and heat stroke during unusually hot weather. If a great deal of time is spent indoors, it is important to maintain even temperature and to avoid extremely humid or dry conditions. Uneven temperatures and humid conditions can increase the likelihood of numerous bacterial and viral infections. On the other hand, dry conditions may contribute to coughing and certain allergic conditions. This is due to the drying of the mucous membrances of the nose and throat.

SUMMARY

Thermal energy in human beings is derived from food consumed. It is essential that heat loss and heat gain be controlled for both human comfort and survival. Such heat control can be accomplished through food and water intake, proper clothing, variations in physical activity, and maintenance of appropriate environmental conditions indoors.

INDIVIDUAL GARMENTS: INSULATION IN CLO UNITS

INSULATION VALUE*	ITEM
0.01	PANTIHOSE
0.02	SANDALS
0.03	COOL SOCKS
0.04	SHOES GIRDLE
0.05	BRIEFS BRAS & PANTIES
0.06	UNDERSHIRT MINI-SKIRT
0.09	T-SHIRT SUMMER SHIRT
0.14	COOL L.S. KNIT SHIRT HALF SLIP
0.19	WOVEN S.S. SHIRT SUMMER BLOUSE
0.26	SUMMER TROUSERS
0.29	WOVEN L.S. SHIRT L.S. BLOUSE
0.32	WARM TROUSERS
0.37	L.S. WINTER SWEATER
0.49	WARM JACKET
0.63	WARM DRESS

* CLO VALUES ARE ADDED FOR EACH GARMENT WORN IN AN ENSEMBLE TO OBTAIN OVERALL CLOTHING INSULATION.

SOURCE: JOHN FLETCHER, ENVIRONMENT, ENERGY AND SOCIETY, 1973.

FIGURE 1.7

CLOTHING MATERIAL CHARACTERISTICS

	COTTON	LINEN	WOOL	SILK	ACETATE	TRIACETATE	ACRYLIC MODACRYLIC	NYLON	OLEFIN	POLYESTER	RAYON
ABSORBENCY	+	+	+	+	-	-		-		-	+
APPEARANCE & HAND				+	+	+	+				+
COLORFASTNESS	+	+	+	+	-		+	+		+	+
DIMENSIONAL STABILITY		+		+	+	+	+/-	+		+	-
DRAPABILITY				+	+	+					+
DURABILITY		+									
DYEABILITY	+		+	+					-		+
ELASTICITY								+			
LAUNDRABILITY	+										
PRESSED-IN CREASE RETENTION	-	-	+	-	-		+			+	
RESILIENCY			+				+	+		+	-

FIGURE 1.8

	COTTON	LINEN	WOOL	SILK	ACETATE	TRIACETATE	ACRYLIC MODACRYLIC	NYLON	OLEFIN	POLYESTER	RAYON
RESISTANCE:											
ABRASION		-		-	-	-	-	+	+	+	-
AGEING				-					+		
CHEMICALS			-				+		+		
FRICTION			-								
HEAT	+	+		-		+					
MILDEW	-	-			+		+	+		+	-
MOTHS	+	+	-		+		+	+	+	+	
PERSPIRATION	+	+	-	-				+	+	+	
PILLING			-				-	-	+		
STAINS									+	-	
SUNLIGHT	-	-	+	-			+	-	+	+	
WEATHER									+	-	
WRINKLING	-	-	+	+	-	+	+	-	+	+	-
SOFTNESS	+						+				-
STRENGTH											
WET	+			-	-	-	-	+		+	
DRY	+			+	-	-	-	+		+	
WARMTH			+				+			+	
WASH & WEAR QUALITY	-		-		-	+	+			+	-
WATER REPELLENCY			-								

SOURCE: "FIBERS AND FABRICS", CONSUMER GUIDE FROM THE NATIONAL BUREAU OF STANDARDS

+ =GOOD TO EXCELLENT

- =FAIR TO POOR

FIGURE 1.8 (CONT.)

APPROXIMATE CALORIC VALUES OF SOME COMMON FOODS

CALORIC VALUES ARE GIVEN IN NUMBERS THAT ARE MULTIPLES OF FIVE TO SIMPLIFY THE ESTIMATING OF TOTAL CALORIES.

FOOD	SIZE OF SERVING	APPROXIMATE CALORIES
FOODS CLASSED AS LARGELY CARBOHYDRATES:		
APPLES, RAW	1 MEDIUM	75
APPLE PIE	1/6 MEDIUM PIE	400
APPLE SAUCE	1/2 CUP	95
APRICOTS, CANNED	3-4 AND 2 T. JUICE	75
APRICOTS, FRESH	2-3	55
APRICOTS, DRIED	4-6 HALVES	100
ASPARAGUS, RAW	8-12 STALKS 5"	25
ASPARAGUS, CREAMED	1/4 CUP	100
BANANAS, FRESH	1 MEDIUM	100
BEANS, STRING, FRESH	1 CUP	25
BEETS, SLICED, FRESH	1 CUP	65
BISCUITS, BAKING POWDER	1 MEDIUM	100
BLACKBERRIES, FRESH	1/2 CUP	40
BLANC MANGE, CHOCOLATE	1/2 CUP	220
BLANC MANGE, PLAIN	1/2 CUP	150
BREAD, WHOLE WHEAT	1 SLICE, 1/2"	55
BREAD, WHITE ENRICHED	1 SLICE, 1/2"	60
BREAD, WHITE, RAISIN	1 SLICE, 1/2"	65
CABBAGE, RAW	1 1/4 CUP	30
CAKE, ANGEL	PIECE 3" CIRCUMFERENCE	140
CAKE, CUP, PLAIN	1 MEDIUM	200
CAKE, PLAIN	PIECE 2" x 1"	110
CAKE, SPONGE, HOT WATER	PIECE 3" CIRCUMFERENCE	155
CANTALOUPE	1/2 MEDIUM	45
CARBONATED BEVERAGES	6 OUNCES	80
CARROTS, RAW	2, 4" LONG	40
CARROTS, STEAMED, CUBED	1/2 CUP	20

FIGURE 1.9

CAULIFLOWER, STEAMED	1 CUP	30
CAULIFLOWER, RAW	1 CUP	25
CELERY	3/4 CUP OR 4 STALKS	20
CHERRIES, SOUR, FRESH, STONED	1 CUP	65
CHERRIES, SWEET, FRESH, STONED	1 CUP	65
CHOCOLATE, BITTER	1 SQUARE	140
CHOCOLATE CREAM MINT	1	50
CHOCOLATE FUDGE	PIECE 1 1/2" x 1" x 3/4"	100
COCOA, POWDERED	1 T.	20
COCONUT, PREPARED	1/3 CUP	115
CORN, CANNED	1/3 CUP	60
CORN, GREEN	1 MEDIUM EAR	85
CORN SYRUP	1/2 CUP	470
CORNFLAKES	1 CUP	50
CORNMEAL, COOKED	2/3 CUP	80
CORNMEAL, RAW	1/4 CUP	130
CORNSTARCH	1 T.	35
CRACKERS, GRAHAM	1	35
CRACKERS, SODA	1	30
CRANBERRY JELLY	2 T.	100
CREAM PIES WITH MERINGUE	1/6 MEDIUM PIE	300
CUCUMBER, FRESH	1/2 CUP OR 1 SMALL	15
DATES, UNSTONED	3-4	85
DOUGHNUTS	1	170
FIGS, DRIED	2 LARGE	100
FLOUR, WHEAT, WHITE, ENRICHED	1 CUP	405
FLOUR, WHOLE WHEAT	1 CUP	400
FRUIT COCKTAIL	3/8 CUP	100
GRAPEFRUIT	1/2 LARGE	100
GRAPENUTS	1/3 CUP	100
GRAPES, CONCORD, DELAWARE	SMALL BUNCH	80
GRAPES, MALAGA, TOKAY	SMALL BUNCH	75
GRIDDLE CAKES	1 CAKE 4" DIAMETER	80
HOMINY GRITS, COOKED	1 CUP	25
HONEY, STRAINED	1 T.	15
LEMON JUICE	1/2 CUP	10
LEMONS	1 MEDIUM	25
LETTUCE	1/4 LARGE HEAD	20

MACARONI, COOKED	1/2 CUP	230
MAPLE SYRUP	1 T.	50
MINCE PIE	1/6 MEDIUM PIE	455
MUFFINS, PLAIN	1 MEDIUM	115
OATS, ROLLED, COOKED	2/3 CUP	100
ONIONS, RAW	1 SMALL OR 3 T.	10
ORANGE JUICE	1/2 CUP	55
ORANGES	1 MEDIUM	50
PARSNIPS, COOKED	1 MEDIUM OR 1 CUP	95
PEACHES, CANNED	1 HALVES, 3 T. JUICE	85
PEACHES, FRESH	1 MEDIUM	50
PEACHES, DRIED	4 MEDIUM HALVES	145
PEARS, CANNED	2 HALVES, 2 T. JUICE	80
PEARS, FRESH	1 MEDIUM	70
PEAS, CANNED	1/2 CUP	55
PEAS, DRIED, RAW	2 T.	85
PEAS, GREEN, SHELLED	3/4 CUP	75
PINEAPPLE, CANNED	1 SLICE, 3 T. JUICE OR 1 1/2 CUPS SHREDDED	90
PINEAPPLE, FRESH	1 CUP	74
POTATOES, SWEET, BAKED	1/2 MEDIUM	100
POTATOES, WHITE, RAW	1 MEDIUM	100
POTATOES, WHITE, CREAMED	1/2 CUP	150
PRUNES, DRIED	4 MEDIUM	75
PRUNES, STEWED	3 MEDIUM AND 2 T. JUICE	100
RAISINS, DRIED SEEDED	3/4 CUP	320
RASPBERRIES, FRESH	3/4 CUP	75
RHUBARB, FRESH	1 CUP	20
RICE, STEAMED	1 CUP	200
RICE PUDDING, CREAMY	1/2 CUP	110
ROLLS, YEAST	1 MEDIUM	120
SALAD, CHICKEN	1/2 CUP	235
SALAD, TOMATO, LETTUCE	1 SERVING	100
SAUCE, WHITE MEDIUM	1/4 CUP	110
SPINACH, COOKED	1/2 CUP	25
SQUASH, HUBBARD, COOKED	1/2 CUP	50
STRAWBERRIES, FRESH	3/4 CUP	40
SUGAR, BROWN	1 T.	50
SUGAR, GRANULATED	1 T.	50

Sugar, powdered	1 T.	30
Sundae, vanilla ice cream with chocolate sauce	1/2 cup	220
Tapioca, cream	1/2 cup	190
Tomato juice	1/2 cup	25
Tomatoes, canned	1/2 cup	25
Tomatoes, fresh	1 medium	30
Turnip greens, cooked	1/2 cup	20
Turnips, cooked	1/2 cup	20
Waffles	1, 6" diameter	215
Watermelon	piece 2 1/2" x 2" x 3"	85
Wheat, shredded	1 large biscuit	100
Yeast, compressed	1 cake	25

Foods classed as largely protein:

Almonds, chocolate	5	105
Almonds, salted	10-12	95
Beans, baked	1/2 cup	100
Beans, Lima, cooked	1/3 cup	100
Beans, navy, cooked	1/2 cup	105
Beef, hamburg steak, broiled	cake, 2 1/3" diameter, 1/2" thick	120
Beef, round, broiled	piece 2 1/2" x 3" x 1/2"	125
Beef, sirloin steak, lean, broiled	piece 4" x 3" x 3/4"	350
Buttermilk	1 cup	85
Cheese, American	1" cube	115
Cheese, cottage	1/3 cup	75
Chicken, lean meat, cooked	3 slices 3 1/2" x 2 1/2" x 1/4"	115
Chocolate beverage made with milk	3/4 cup	210
Eggs, scrambled	1/2 cup	180
Eggs, whole	1	75
Fish, lean, broiled	piece 4" x 2 1/4" x 2/3"	125
Gelatin, granulated	1 T.	35
Ham, baked	piece 4" x 2 1/2" x 3/4"	280
Ham, boiled	1 oz.	85
Ice cream, vanilla	1/3 cup	150
Jello	1/3 cup	75
Junket, plain	1/2 cup	115

LAMB CHOP, BROILED	1	250
LAMB ROAST	SLICE 3 1/2" x 4 1/2" x 1/8"	200
LIVER, RAW	PIECE 4" x 3" x 5/8"	130
MILK, SKIMMED	1 CUP	85
MILK, WHOLE	1 CUP	165
OYSTERS, RAW	1/3 CUP OR 3 1/2 LARGE	70
PORK CHOP, BROILED	1 MEDIUM	250
SALMON, CANNED	1/2 CUP	205
SODA WATER WITH VANILLA ICE CREAM	2/3 GLASS	200
SOUP, CREAM OF PEA	1/2 CUP	135
SOUP, CREAM OF TOMATO	1/2 CUP	125
WALNUTS, ENGLISH	10 MEATS OR 1 1/2 T. CHOPPED	100

FOODS CLASSED AS LARGELY FAT:

BACON, COOKED	2 SLICES	100
BUTTER	1 T.	100
COD LIVER OIL	1 T.	100
COTTONSEED OIL	1 T.	125
CREAM, 40%	1/2 CUP	440
CREAM, 18%	1/2 CUP	245
FRENCH SALAD DRESSING	1/2 CUP	470
LARD	1 T.	125
MAYONNAISE DRESSING	1 T.	90
OLEOMARGARINE, FORTIFIED	1 T.	110
OLIVES, GREEN, UNSTONED	3-4	50
OLIVE OIL	1 T.	135
PEANUT BUTTER	1 T.	90
PEANUTS, SHELLED, ROASTED	9-10	50
RUSSIAN SALAD DRESSING	1 T.	100

HUMAN COMFORT AND ENERGY CONSERVATION
UNIT II
HOW NATURAL CLIMATES AND ARTIFICIAL ENVIRONMENTS ARE DEFINED

GOAL STATEMENT

After completion of Unit II, the student will recognize the effects of air temperature, humidity and windspeed on the human body; changes in heat balance produced by air movement and seasonal weather conditions; will be familiar with the characteristic climates of several Texas cities, and be able to plot these climates on a comfort chart.

UNIT OBJECTIVES

Upon completion of this unit the student will be able to:

1. Differentiate between TDB and TWB.
2. Explain how surface temperature is important.
3. Explain how air movement can have a cooling effect on the body.
4. Explain how relative humidity is related to human comfort.
5. Explain the meaning of the term, "residentially acclmatized."
6. Define isotherm.
7. List four factors that are important in determining local climatology.
8. Explain what determines humidity.
9. List the three factors upon which human comfort zones rely.
10. Describe the function of the globe thermometer.
11. Give two reasons why, in warm indoor environments, comfort is dependent upon air movement.
12. Be able to plot a comfort zone on a psychometric chart.

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

UNIT II

HOW NATURAL CLIMATES AND ARTIFICIAL ENVIRONMENTS ARE DEFINED

LECTURE	ACTIVITIES

a. Characteristics of Hot and Cold Air

When the air is still and at a fixed mid-humidity level, and the dry bulb temperature (T_{DB}) is higher than the skin temperature (T_{SK}), the air feels warm. However, if the T_{DB} is lower than the T_{SK}, the air feels cool.

On the other hand, if the air is moving, the body feels cooler because heat is lost from your body by evaporation. Obviously, the sensation of cold is magnified with an increase of air movement. Additionally, when the surface temperature (T_{surf}) of nearby windows, walls, floors, and ceilings are significantly higher or lower than a comfortable dry bulb temperature reading, one feels uncomfortable. Therefore, variations in comfort depend primarily upon the difference between the T_{DB} and the T_{surf}. However, it should not be forgotten that such variations in comfort also depend upon clothing, activity level, air movement, and humidity level. Outdoors, T_{surf} is replaced by sky temperature, solar radiation, ground temperature, and wall temperature.

Turn to Figure 2.1 and discuss the information found there.

In studying Figure 2.1 it should be noted that the average change in the T_{DB} necessary for staying in the comfort zone is much smaller in range than the monthly range of average outdoor temperatures. You should also note that the T_{SK} for comfort is somewhat narrow in range.

In measuring maximum and minimum temperatures either a maximum-minimum thermometer or a thermograph may be used.

Mount maximum-minimum thermometers side-by-side with thermographs for a 24 hour period: (a) outdoors, (b) in a non-air conditioned buildings, and (c) in an air conditioned space. Note that the maximum-minimum thermometers record only the highest and lowest temperature (T_{DB}) in the 24 hour period. By contrast the thermographs give two additional items of information: (1) when these temperatures were achieved, and (2) how long the temperatures remained above or below any designed temperature range (i.e., T_{SK}). Is there much difference between (a), (b) and (c)? Why?

MAXIMUM AND MINIMUM TEMPERATURES

Mean Temperature*		Max. F	Min. F	Range F
TSK	(comfort)	95°	91°	4°
TDB	(comfort)	93°	72°	19°
TSK	(outdoors)	100°	75°	25°
TDB	(outdoors-Texas)	98°	20°	78°
TDB	(outdoors-Continental USA)	105	-3	108
T (surf)	(outdoors-** Texas)	139°	6°	133°
T (surf)	(outdoors-** Continental USA)	168°	NA	NA

---

*Individual reactions to temperature may vary substantially. The mean TSK is usually the average skin temperature for feet, lower and upper leg, trunk, arms, hands and head. However, the feet and leg temperatures ARE usually much more variable than the trunk and head TSK. Outdoor TDB are average monthly air temperatures for July and January (max.°F and min.°F, respectively). Mean T (surf) outdoors is the mean of shade and exposed ground temperatures and sky temperature and surface temperature of nearby objects.

** Estimated 1-hour averages on light surfaces. Computer models for dark surfaces predict occasional values as high as 198°F for one hour.

FIGURE 2.1

b. Air Movement and Humidity

The velocity of air movement (or windspeed) ($V\text{-}_{air}$) and the wet bulb temperature both affect human comfort.

Air movement ($V\text{-}_{air}$) is produced by fans, wind, or natural ventilation. The $V\text{-}_{air}$ is measured by a vane gauge anemometer. The wet bulb temperature is measured by a regular thermometer that has its bulb covered with a moist, loosely knit cover and exposed to air movement.

Mount a vane gauge anemometer and a sling psychrometer (commonly called a wet-and-dry bulb psychrometer) in front of a moving fan. Also place two beakers of hot water nearby--one covered with a lid and the other open. Run the fan for one hour and take temperature readings periodically. Verify the table in Figure 2.2.

ACTIVITY

TIME	TDB	CLOSED CONTAINER	TWB	OPEN CONTAINER
BEFORE STARTING FAN	SAME AS AIR TEMPERATURE	HOT (T_{HOT})	SAME AS AIR TEMPERATURE	HOT (T_{HOT})
AFTER 5 MINUTES	AS ABOVE	STILL HOT	DROPS	SOMEWHAT COOLER
AFTER 30 MINUTES	AS ABOVE	SOMEWHAT COOLER	NO FURTHER CHANGE*	COOLER THAN CLOSED CONTAINER
AFTER 60 MINUTES	AS ABOVE		NO FURTHER CHANGE*	MUCH COOLER

*IF THE WICK IS ALLOWED TO GO DRY, NOTE THAT TWB WILL RISE UNTIL TWB = TDB. CONFIRM THIS. KEEP THE WICK MOIST FOR ACCURATE TWB READINGS.

FIGURE 2.2

Air movement produces cooling of both closed and open containers from T_{Hot} towards T_{DB}. If the surroundings air is humid, T_{WB} will drop only two or three degrees. If the surroundings air is dry, T_{WB} will drop four to six degrees or more. The difference between T_{DB} and T_{WB} minus T_{WB} is called the evaporative cooling effect. This can be used to measure air humidity.

The rate of temperature drop of surface to value ratio for the two water-filled containers will depend on their size, or V_{air}, and /or T_{Hot}, T_{DB}, T_{WB}. Cooling will be slow if the containers are large and completely filled, and if T_{Hot} is substantially greater than T_{DB} and T_{WB}. Cooling will be rapid if the containers are small or underfilled, and if T_{Hot} is only a few degrees above T_{DB} and T_{WB}. The closed container will cool due to passage of cool air over warm surface or convective cooling. The open container will cool due to combined convective cooling and evaporative cooling. The combined effect is greater than either effect measured singly. The rate of evaporative cooling increases with temperature for dry air, but the rate of convective cooling decreases.

c. Natural Outdoor Conditions vs Season And Geography

Residentially acclimatized persons form distinct groups in regard to their comfort. Those living in the tropics between latitudes 23.5°N and 23.5°S are acclimatized to temperature between 60°F and 100°F. However, individuals residing in temperate zones between latitudes 23.5° and 66.1°N and S are typically acclimatized to temperatures between 53°F and 93°F.

Figure 2.3 is a temperature/humidity comfort chart that shows the relationship between T_{DB} and humidity. Notice that residents of Texas fall in a bell-shaped intermediate subtropical zone between the two shaded areas on the chart in Figure 2.3.

Discuss convective cooling and evaporative cooling in relation to student experience at the swimming pool:

(a) on removal of top clothing

(b) on climbing out of the pool--still day

(c) on climbing out of the pool--windy day

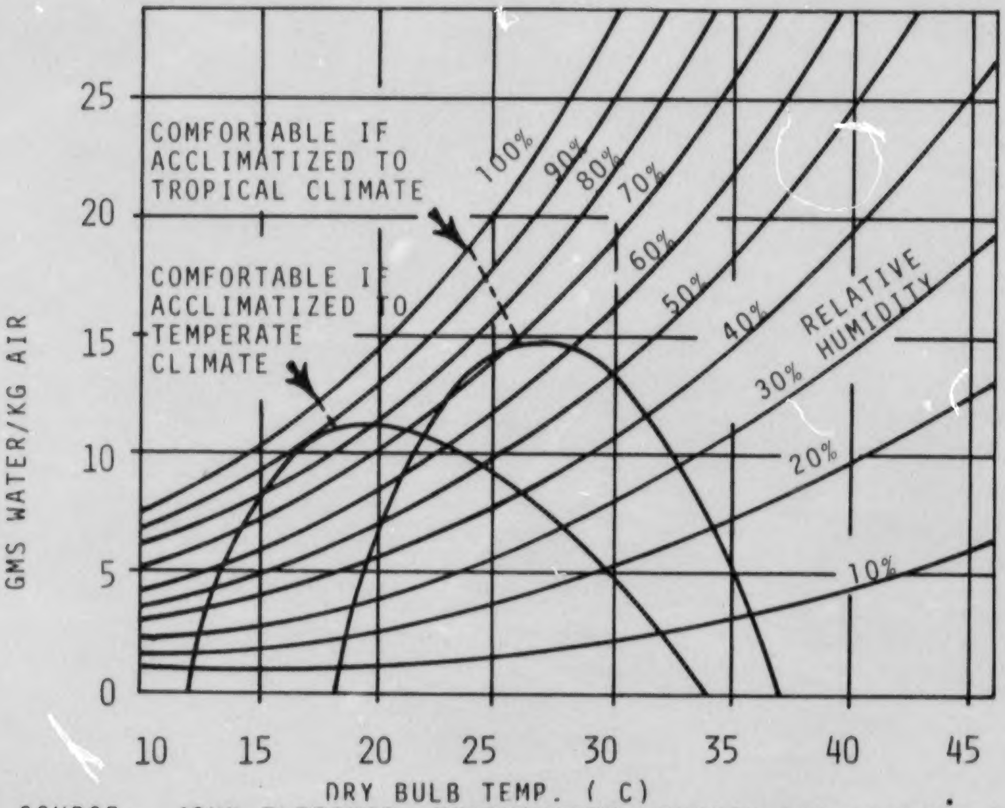
(d) on sitting in wet swim suits

(e) on sitting in wet clothing

(f) on changing from wet to dry clothing.

Is there any difference between the hot, wet conditions of a coastal city such as Houston or Galveston, and the hot, dry conditions of El Paso or Midland in summer?

TEMPERATURE--HUMIDITY--COMFORT RELATIONSHIPS



SOURCE: JOHN FLETCHER, ENVIRONMENT, ENERGY AND SOCIETY, 1973.

FIGURE 2.3

Look at Figure 2.4. The lower map in the figure shows July isotherms. Notice that Texas is intersected by the July 30°C (86°F) isotherm. When reduced to sea level equivalents, the results shown that the western portion of Texas is one of the hottest areas in the world. Look at Figure 2.5. This chart gives record highs and average highs for the month of July as well as average lows and record lows for the month of January.

If you look again at Figure 2.4, you will see that neither summer nor winter temperatures are uniform in relation to degrees of latitude. Notice that the upper map of Figure 2.4 contains lines drawn to connect all points with average January temperatures of 20°C (68°F), 10°C (50°F), (32°F), -10°C (140°F) et cetera. These lines connecting places of equal average tempera-

Study the world isotherm map and determine the coldest month in the Northern Hemisphere (January). Locate Texas. Between what two temperatures does the monthly average lie? Discuss.

Study the world isotherm map and determine the warmest month in the Northern Hemisphere (July). Locate East Texas and West Texas. Is there a difference between their monthly average temperatures? Discuss.

For one month, plot the temperature and precipitation for your home, city or nearest one listed at Figure 2.5.

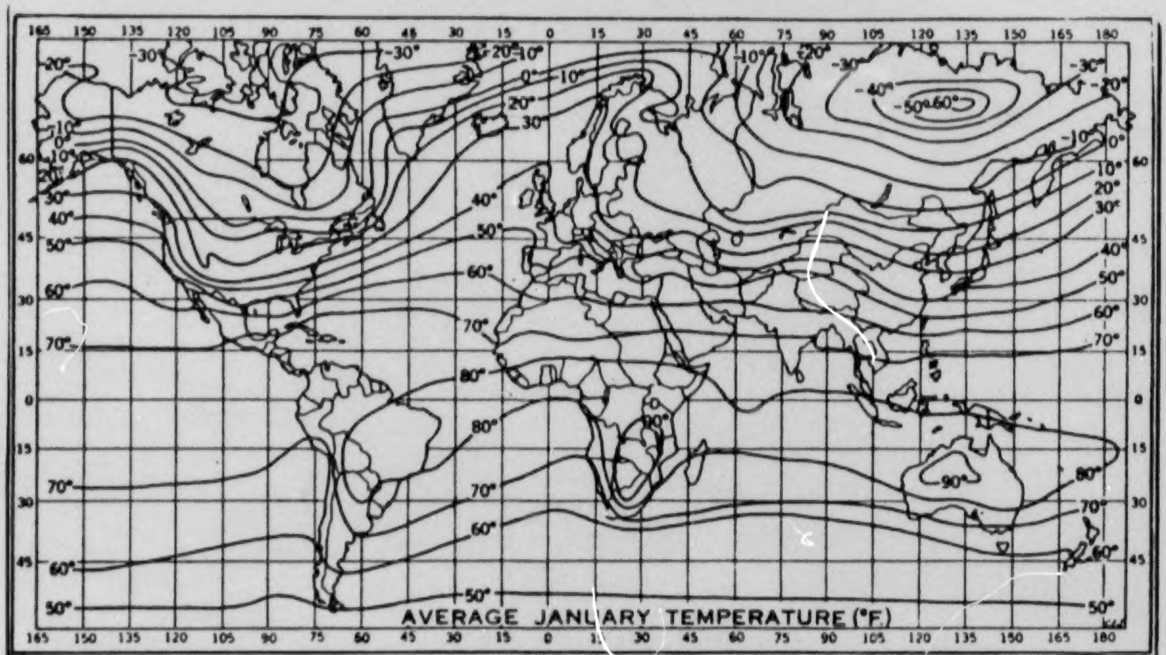
tures are called isotherms. Although local climatology is determined by numerous factors, some of the more important ones include latitude, longitude, altitude, and natural atmosphere flow patterns.

On the same graph, also plot temperate and humidity for:

Houston
El Paso
Amarillo

Note the differences and explain reasons for these.

WORLD ISOTHERM MAPS--JANUARY AND JULY


AVERAGE JANUARY TEMPERATURE (°F)
AVERAGE JULY TEMPERATURE (°F)
165 150 135 120 105 90 75 60 45 30 15 0 15 30 45 60 75 90 105 120 135 150 165 180
-30°
-20°
-10°
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
-40°
-50°
-60°

SOURCE: U.S. WEATHER BUREAU FIGURE 2.4

CLIMATOLOGICAL AVERAGES AND EXTREMES

	TEMPERATURE (°F)				PRECIPITATION (INCHES)												
	A	B	C	D	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
ABILENE	94	33	111	- 9	.88	1.09	1.04	2.27	4.33	2.67	2.28	1.47	2.07	2.85	1.11	1.26	23.32
AMARILLO	92	21	108	-16	.65	.62	.82	1.32	3.37	2.89	2.34	2.58	1.89	1.76	.66	.77	19.67
ANGLETON	91	46	105	10	3.63	3.84	3.18	3.20	3.90	3.51	5.53	4.82	5.44	3.80	3.70	4.61	49.16
AUSTIN	95	41	109	- 2	2.35	2.58	2.13	3.55	3.71	3.22	2.18	1.94	3.44	2.83	2.12	2.53	32.58
BAY CITY	93	43	106	11	3.00	3.03	2.17	2.91	4.32	4.20	3.34	4.83	5.83	3.65	3.09	3.47	43.84
BEAUMONT	93	44	108	4	4.57	4.38	2.82	4.43	4.79	4.75	5.71	5.34	5.30	3.19	4.54	4.95	54.77
BEEVILLE	95	45	111	5	2.08	1.76	1.78	2.44	3.24	2.99	2.87	2.20	3.64	2.48	1.90	2.23	29.61
BRENHAM	95	43	111	- 2	3.22	3.11	2.74	3.58	4.18	3.29	2.88	2.88	2.88	2.86	3.81	3.89	39.12
BROWNSVILLE	93	52	104	12	1.36	1.31	1.07	1.37	2.55	2.63	1.73	2.54	5.51	3.22	1.78	1.55	26.65
CLEBURNE	96	35	114	- 3	2.04	2.64	2.35	3.79	4.46	2.92	2.17	2.25	2.78	2.94	2.28	2.58	33.20
CORPUS CHRISTI	94	47	105	11	1.63	1.70	1.44	2.14	2.99	2.39	2.32	2.77	4.40	2.76	1.72	2.08	28.34
CORSICANA	96	36	113	- 7	2.86	3.00	2.88	4.32	4.98	3.12	1.90	2.19	2.67	2.96	2.97	3.21	37.06
DALLAS	95	36	111	- 3	2.32	2.55	2.85	4.00	4.83	3.24	1.94	1.93	2.82	2.70	2.70	2.67	34.55
DENISON DAM	95	31	109	2	1.62	2.62	2.53	4.65	4.77	3.88	2.81	2.49	3.92	2.81	2.55	2.22	36.87
DENTON	96	34	113	- 3	1.90	2.42	2.51	3.69	5.03	3.16	2.05	1.73	2.37	2.46	2.05	2.19	31.56
DUMAS	93	20	109	-18	.60	.54	.78	1.30	2.95	2.45	2.60	2.62	1.55	1.60	.64	.70	18.33
EL PASO	94	32	109	- 8	.46	.41	.35	.29	.40	.69	1.29	1.19	1.14	.85	.33	.49	7.89
FORT WORTH	96	35	112	- 8	2.04	2.24	2.51	3.60	4.59	2.98	1.75	1.68	2.54	2.59	2.46	2.35	31.33
GAINESVILLE	96	32	114	-12	2.07	2.51	2.64	3.75	5.09	3.79	2.38	2.45	2.63	2.91	2.09	2.23	34.54
GALVESTON	87	42	101	8	3.46	2.88	2.86	2.59	2.79	2.65	4.79	4.39	5.09	2.86	1.56	3.89	41.81
GONZALES	96	42	106	18	2.15	2.32	1.96	3.55	3.71	2.91	2.79	2.43	3.54	2.42	2.42	2.53	32.73
GREENVILLE	94	34	116	- 4	2.89	3.31	3.56	4.75	5.72	4.20	3.18	2.27	2.92	3.21	3.54	3.26	42.81
HOUSTON	93	45	109	5	3.78	3.44	2.67	3.24	4.32	3.69	4.29	4.27	4.26	3.77	3.86	4.36	45.95
KERRVILLE	94	34	110	- 7	1.86	2.07	2.02	3.07	4.19	2.99	2.32	1.85	4.22	3.14	1.52	2.25	31.50
KINGSVILLE	96	48	108	11	1.65	1.50	1.30	2.05	3.00	2.30	2.00	2.50	4.75	2.45	1.38	1.62	26.50
LUBBOCK	92	25	107	-16	.68	.57	.73	1.15	3.18	2.53	2.01	1.68	2.36	2.00	.54	.65	18.08
MARSHALL	95	37	112	- 9	4.75	4.01	4.40	4.43	5.25	3.18	3.28	2.53	2.70	3.01	4.41	5.01	46.96
McALLEN	96	48	106	17	1.18	1.03	.66	1.56	2.19	2.36	.88	1.84	3.69	2.58	.98	.84	19.79
McKINNEY	96	34	118	- 7	2.21	2.59	2.78	3.97	5.28	3.22	2.42	1.78	2.82	2.95	2.61	2.17	34.80
MEMPHIS	98	26	117	-11	.76	.77	.89	1.76	4.28	2.78	1.84	1.62	2.07	2.01	.50	.63	19.91
MIDLAND	95	31	109	-11	.80	.60	.36	.83	2.08	1.63	1.88	1.48	1.79	1.66	.47	.66	14.24
MULESHOE	92	20	110	-21	.65	.48	.62	1.02	2.80	2.48	2.37	2.21	1.99	1.62	.55	.65	17.44
PAMPA	94	23	109	-12	.53	.69	.79	1.50	3.62	3.00	2.48	2.39	1.91	1.83	.61	.81	20.16
PARIS	94	34	115	-13	3.08	3.45	3.47	5.19	5.40	4.26	3.65	2.73	3.52	3.22	3.78	3.36	45.11
PLAINVIEW	93	26	108	- 8	.80	.62	.68	1.53	3.18	2.58	2.47	2.05	2.02	1.64	.59	.82	18.96
PORT ARTHUR	91	44	107	11	4.23	4.45	3.44	3.94	4.94	4.29	6.00	5.49	4.88	2.88	3.46	5.09	53.09
SAN ANTONIO	94	42	107	0	1.74	1.65	1.67	2.82	3.45	2.95	2.09	2.36	3.49	2.50	1.37	1.75	27.84
TYLER	94	37	106	- 8	3.98	3.67	3.91	4.89	5.45	3.27	3.26	2.91	2.74	3.23	4.21	4.77	46.19
VICTORIA	92	46	110	9	2.34	2.34	2.32	2.62	4.12	3.04	3.61	3.13	4.23	3.45	2.36	2.61	36.20
WACO	96	38	112	- 5	2.27	2.42	2.35	3.88	4.57	2.67	1.99	1.66	2.77	2.55	2.19	2.74	32.06
WEATHERFORD	96	34	113	-11	2.14	2.46	2.16	3.58	5.39	3.00	1.80	1.67	2.70	3.04	1.82	2.12	31.37
WICHITA FALLS	97	31	113	-12	1.12	1.38	1.54	2.53	4.60	3.20	1.97	1.79	2.33	3.87	1.42	1.45	26.20

A - Average July Temperature
B - Average January Temperature
C - Record Highest
D - Record Lowest

Because human comfort is highly dependent upon humidity, one might ask, "What determines humidity?" Humidity depends upon a number of factors: (1) average precipitation, (2) time since last rainfall, (3) wind direction, (4) wind speed, (5) time of day, and (6) cloud cover. Such information can be found in a full climatological table which, in addition to the data mentioned above, also lists monthly and yearly temperatures, degree-days of heating and cooling, relative humidity, days of sunshine, and data concerning thunder and fog. Examples of such data are given for five Texas cities in Figure 2.6 a-e. Each National Weather Station publishes monthly and annual climatological data for its area.

AMARILLO, TEXAS / ***elevation 3590 feet***

	Temperature				Degree Days	Rel. Hum. (1)	Precipitation		Wind		% Poss Sun	Average Number of Days of							Sun-rise 15th	Sun-set 15th	% IFR
	Average		Extreme									Rain .01"	Snow 1.0"	Thun	Fog	Sunup/Sundown					
	Max	Min	Max	Min			Total	Snow	mph	Dir						clr	pc	clo			
Jan	49	22	81	−11	921	52	1	4	13	sw	67	4	1	*	2	12	7	12	7:55	5:58	5
Feb	54	26	82	−14	733	50	1	3	14	sw	66	4	1	*	4	10	7	11	7:33	6:29	12
Mar	61	31	92	−3	586	43	1	2	15	sw	70	4	*	1	4	12	9	10	6:58	6:54	9
April	70	41	94	14	298	42	1	1	15	sw	71	6	*	4	2	11	9	10	6:15	7:19	7
May	78	50	102	28	99	47	3	T	14	s	70	9	0	9	2	10	11	10	5:43	7:44	9
June	88	59	108	42	0	43	3	0	14	s	76	8	0	9	1	13	12	5	5:32	8:03	3
July	92	64	104	53	0	44	2	0	12	s	77	9	0	11	1	13	13	5	5:43	8:02	4
Aug	90	63	106	49	0	43	3	0	12	s	78	8	0	9	*	15	11	5	6:06	7:36	1
Sept	83	56	102	33	37	44	2	T	13	s	77	5	0	4	1	17	7	6	6:20	6:54	5
Oct	73	45	95	25	210	47	2	T	13	sw	73	5	0	3	2	16	7	8	6:53	6:12	5
Nov	60	31	85	3	594	43	1	1	13	sw	76	3	*	*	2	17	7	6	7:22	5:41	4
Dec	51	24	81	5	859	49	1	2	13	sw	68	4	1	*	2	14	7	10	7:48	5:36	4
Year	71	43	108	−14	4345	46	21	13	14	s	73	69	3	50	23	160	107	98	......	......	6

elevation 3920 feet / EL PASO, TEXAS

	Temperature				Degree Days	Rel. Hum. (1)	Precipitation		Wind		% Poss Sun	Average Number of Days of							Sun-rise 15th	Sun-set 15th	% IFR
	Average		Extreme													Sunup/Sundown					
	Max	Min	Max	Min			Total	Snow	mph	Dir		Rain .01"	Snow 1.0"	Thun	Fog	clr	pc	clo			
Jan	56	31	75	−6	670	44	T	2	10	N	75	3	1	*	1	13	8	10	8:06	6:24	3
Feb	62	36	81	8	458	36	T	1	11	N	79	3	*	*	*	[illegible]	7	7	7:48	6:52	1
Mar	68	41	88	18	330	29	T	1	13	WSW	81	2	*	1	*	14	8	9	7:16	7:14	1
April	77	49	95	28	110	26	T	T	13	WSW	85	2	0	1	*	16	8	6	6:37	7:34	2
May	85	58	104	38	0	23	T	0	12	W	88	2	0	3	0	19	8	4	6:09	7:55	1
June	94	67	109	50	0	25	1	0	11	W	88	4	0	5	0	19	8	3	5:59	8:12	1
July	94	69	109	60	0	36	1	0	10	S	77	8	0	10	0	12	13	6	6:10	8:12	1
Aug	92	68	103	59	0	39	1	0	10	S	80	7	0	11	0	14	13	4	6:30	7:49	1
Sept	87	63	103	41	0	37	1	0	9	S	82	4	0	3	*	19	6	5	6:49	7:12	1
Oct	78	52	93	32	70	37	1	0	9	N	82	4	0	2	*	18	8	5	7:09	6:34	2
Nov	66	38	84	16	390	36	T	T	10	N	84	2	*	*	*	19	6	5	7:34	6:06	1
Dec	57	33	76	5	626	42	T	1	10	N	77	3	*	*	*	17	6	8	7:58	6:03	1
Year	76	50	109	−6	2641	34	8	4	11	N	82	44	1	36	1	194	99	72	......	......	1

HOUSTON, TEXAS / *elevation 41 feet*

	Temperature				Degree Days	Rel. Hum. (1)	Precipitation		Wind		% Poss Sun	Average Number of Days of							Sun-rise 15th	Sun-set 15th	% IFR
	Average		Extreme													Sunup/Sundown					
	Max	Min	Max	Min			Total	Snow	mph	Dir		Rain .01"	Snow 1.0"	Thun	Fog	clr	pc	clo			
Jan	62	46	82	10	378	66	4	T	11	N	46	10	*	2	3	8	7	16	7:18	5:44	23
Feb	66	50	90	14	247	65	3	T	11	SE	44	10	*	2	2	6	7	15	7:01	6:10	25
Mar	71	54	96	21	166	59	3	0	12	SE	51	9	0	2	2	8	8	15	6:32	6:30	12
April	78	61	92	39	27	60	3	0	12	SE	54	8	0	5	1	7	8	15	5:55	6:48	11
May	85	67	95	46	0	59	5	0	11	SE	63	8	0	6	1	6	12	13	5:29	7:07	9
June	90	74	99	57	0	58	4	0	10	S	70	8	0	7	*	7	15	8	5:20	7:23	1
July	92	75	105	68	0	58	4	0	8	S	69	10	0	11	0	6	16	9	5:31	7:24	1
Aug	93	75	103	63	0	59	3	0	8	S	68	9	0	9	*	7	15	9	5:49	7:02	4
Sept	89	71	99	45	0	59	4	0	9	SE	64	9	0	5	*	9	11	10	[illegible]	6:27	5
Oct	82	63	97	37	0	56	3	0	9	SE	67	7	0	3	2	12	10	9	6:23	5:51	10
Nov	71	53	89	28	162	58	4	0	10	SE	57	8	0	2	2	10	8	12	6:46	5:26	13
Dec	64	47	83	20	303	64	5	T	10	SE	48	10	0	2	3	9	6	16	7:09	5:24	18
Year	79	61	105	10	1276	60	45	T	10	SE	59	106	*	56	16	95	123	147	......	......	11

elevation 16 feet / BROWNSVILLE, TEXAS

	Temperature				Degree Days	Rel. Hum. (1)	Precipitation		Wind		% Poss Sun	Average Number of Days of							Sun-rise 15th	Sun-set 15th	% IFR
	Average		Extreme													Sunup/Sundown					
	Max	Min	Max	Min			Total	Snow	mph	Dir		Rain .01"	Snow 1.0"	Thun	Fog	clr	pc	clo			
Jan	70	51	87	23	219	65	1	T	12	SSE	47	7	0	1	4	7	8	16	7:18	6:00	14
Feb	73	54	94	22	109	65	1	T	13	SSE	49	7	0	1	5	7	6	15	7:05	6:23	18
Mar	77	59	99	32	74	62	1	T	14	SE	48	5	0	1	3	6	9	16	6:39	6:38	14
April	82	65	100	45	0	60	2	0	14	SE	53	4	0	2	3	5	11	14	6:07	6:53	9
May	87	71	100	53	0	60	3	0	14	SE	66	4	0	3	1	7	15	9	5:44	7:08	5
June	91	74	101	49	[illegible]	60	3	0	13	SE	[illegible]	5	0	2	*	7	17	6	5:38	7:23	4
July	93	75	103	68	0	55	2	0	12	SE	81	4	0	2	0	12	14	5	5:47	7:24	1
Aug	93	75	100	66	0	56	2	0	11	SE	77	7	0	4	0	10	15	6	6:02	7:06	1
Sept	90	73	104	55	0	60	5	0	10	SE	68	10	0	4	*	9	14	7	6:15	6:34	2
Oct	86	66	95	43	0	61	3	0	10	SE	68	7	0	2	1	12	12	7	6:28	6:02	5
Nov	77	58	94	34	59	61	2	0	11	SSE	52	7	0	1	2	8	9	13	6:48	5:41	6
Dec	72	53	88	29	159	64	2	0	11	NNW	47	6	0	*	5	7	8	16	7:09	5:41	14
Year	83	65	104	22	617	61	28	T	12	SE	61	73	0	23	24	97	138	130	……	……	8

DALLAS, TEXAS / *elevation 476 feet*

	Temperature				Degree Days	Rel. Hum. (1)	Precipitation		Wind		% Poss Sun	Average Number of Days of							Sun-rise 15th	Sun-set 15th	% IFR
	Average		Extreme													Sunup/Sundown					
	Max	Min	Max	Min			Total	Snow	mph	Dir		Rain .01"	Snow 1.0"	Thun	Fog	clr	pc	clo			
Jan	55	36	88	2	607	62	2	1	10	S	47	7	1	1	1	9	5	17	7:30	5:44	17
Feb	60	40	88	7	445	61	3	T	11	S	50	8	*	3	1	8	6	14	7:11	6:13	11
Mar	68	47	96	11	288	54	3	T	13	S	56	8	*	4	1	10	8	13	6:38	6:35	7
April	77	56	96	31	75	56	4	0	13	SSE	58	9	0	6	*	9	8	13	5:58	6:57	10
May	84	64	99	39	0	56	5	0	12	S	63	9	0	7	*	9	10	12	5:29	7:19	3
June	92	72	105	53	0	53	3	0	12	S	75	6	0	5	*	13	11	6	5:19	7:37	1
July	95	76	111	61	0	50	2	0	10	S	78	5	0	4	*	15	9	7	5:30	7:37	2
Aug	96	76	109	61	0	48	2	6	10	SSE	77	6	0	4	*	16	10	5	5:50	7:13	1
Sept	89	69	105	36	0	49	3	0	9	SE	74	5	0	3	*	16	8	6	6:11	6:34	4
Oct	80	58	99	30	53	51	3	0	9	SE	66	6	0	3	1	15	7	9	6:31	5:55	5
Nov	66	45	89	17	299	51	2	T	10	S	63	6	0	2	1	14	6	10	6:57	5:26	10
Dec	58	39	89	12	518	58	3	T	10	SSE	54	6	*	1	2	11	6	14	7:22	5:23	10
Year	77	56	111	2	2272	54	35	2	11	S	66	81	1	43	7	145	94	126	……	……	7

d. How Human Comfort Zones are Measured

Although human comfort zones are measured in several different ways, all of them rely upon T_{DB}, T_{WB}, and V_{air}.

In areas of high temperature or intense sunshine, the T globe replaces the T_{DB}. The T globe is determined by a Globe Thermometer as pictured in Figure 2.7. Notice that a thermometer is inserted to the center of a copper sphere (six inches in diameter) with a black matt surface. T globe describes the combined physical effects of T_{DB}, V_{air}, and radiant heat by measuring the average radiant temperature.

GLOBE THERMOMETER FOR DETERMINING MEAN RADIANT TEMPERATURE

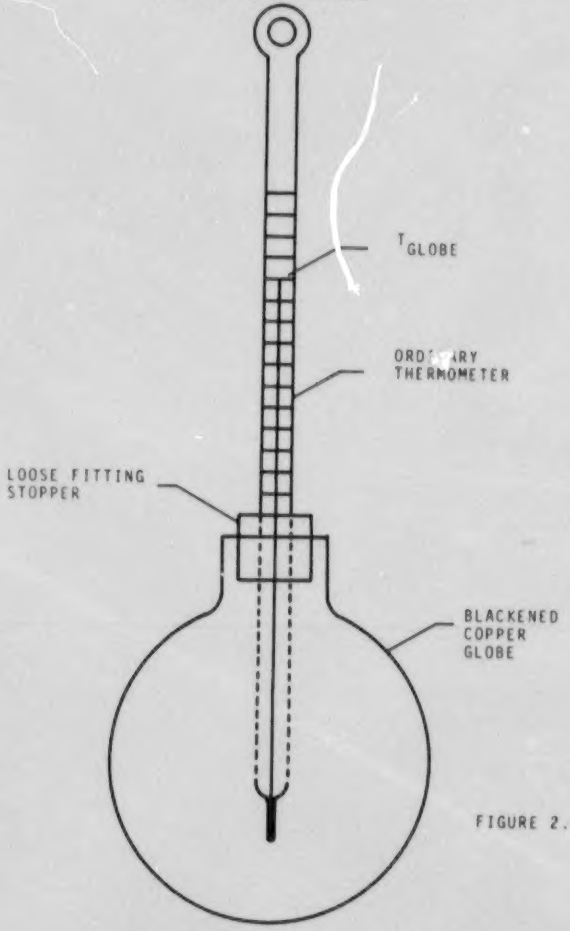


FIGURE 2.7

V_{air} Graph

Measure T_{DB}, T_{WB}, V_{air} in the laboratory and outside at the present time using a sling psychrometer and vane gauge anemometer. Locate both V_{air} values on the graph. The study of radiant effects is complex. The mean radiant temperature in an enclosed space is the mean of all the surfaces enclosing the space in proportion to their areas and temperatures. The effect of a large areas of window, which may be cold in winter and hot in summer, produces variations in different parts of a room. Moreover, the body itself is sizable, and its response varies according to differences of clothing. These effects are measured by T globe, including such changes as are caused by introducing heated surfaces to warm the space and by the entrance of heat through windows via sunshine.

Use comfort zone chart at Figure 2.3. Show how one's comfort index value changes with changes in temperature, humidity, and wind speed.

In warm indoor environments, our comfort is quite dependent upon air movement because:

(1) it permits cooling by evaporation;

(2) it removes the insulating layer of still air above the skin and clothing.

Moderate air movement (V_{air} = 200-400 feet per unit or 2 1/4 to 4 1/2 mph) are very effective in helping to cool the body in surrounding temperature of 77°F to 95°F. Air movements above 400 feet per minute tend to disturb dust and papers. However, when air is moving at 200 feet per minute there is less convective cooling and an increased sense of warmth. This is probably desirable below 77°F but undesirable above 77°F.

Look at Figure 2.8. This shows the effect of varying air movements upon the "clo" value of the insulating layer of air above the skin and clothing. Notice that as the velocity of the air increases the "clo" value of the insulating air above one's skin decreases. This explains why ceiling fans and large pedestal fans help one feel more comfortable in warm surroundings.

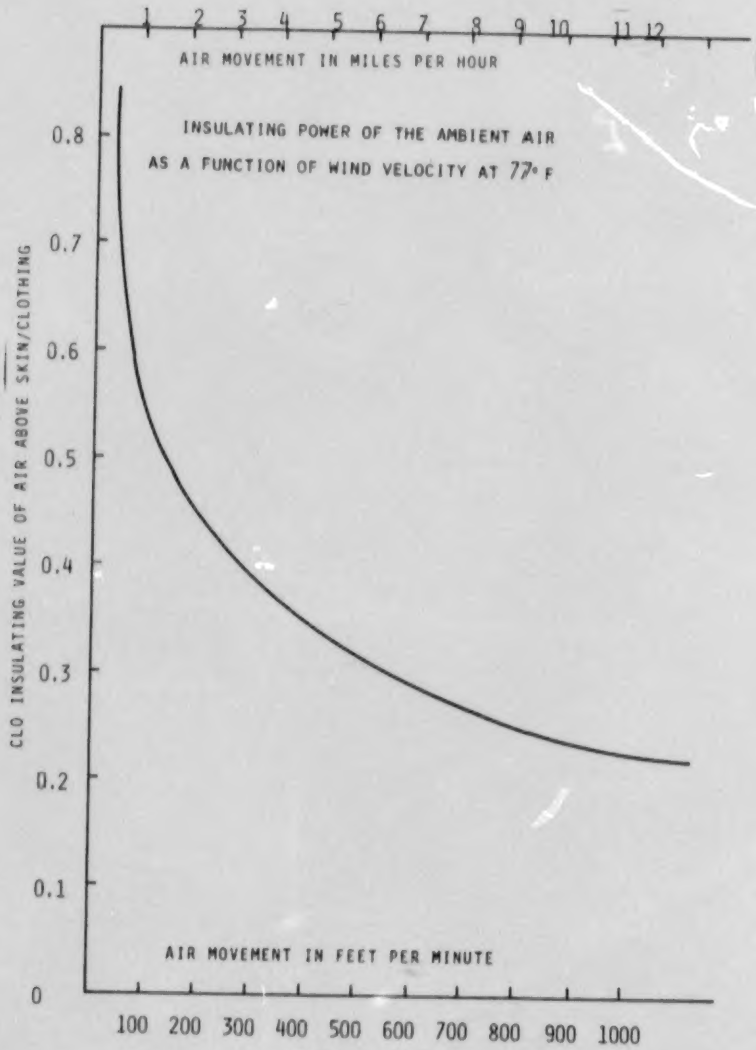


FIGURE 2.8

Either indoors or outdoors, when the temperature is between 65°F and 77°F both T_{DB} and T_{WB} are important. Between these temperatures a relative humidity (RH) between 20% and 60% is preferred for comfort. When the RH is above 60% (at temperatures between 65°F and 77°F) the air begins to feel moist and evaporative cooling is reduced. If the relative humidity is above 85%, the skin feels "sticky." Below 20% RH, the air feels dry and the skin tends to dry and even occasionally crack.

Verify that 20% RH, 60% RH, 65°F, 72°F and 77°F have been plotted correctly on the T_{DB}/T_{WB} chart at figure 2.9. On the chart, can you write in the summer and winter T_{DB} and T_{WB} for any selected Texas City, using the table at Figure 2.10?

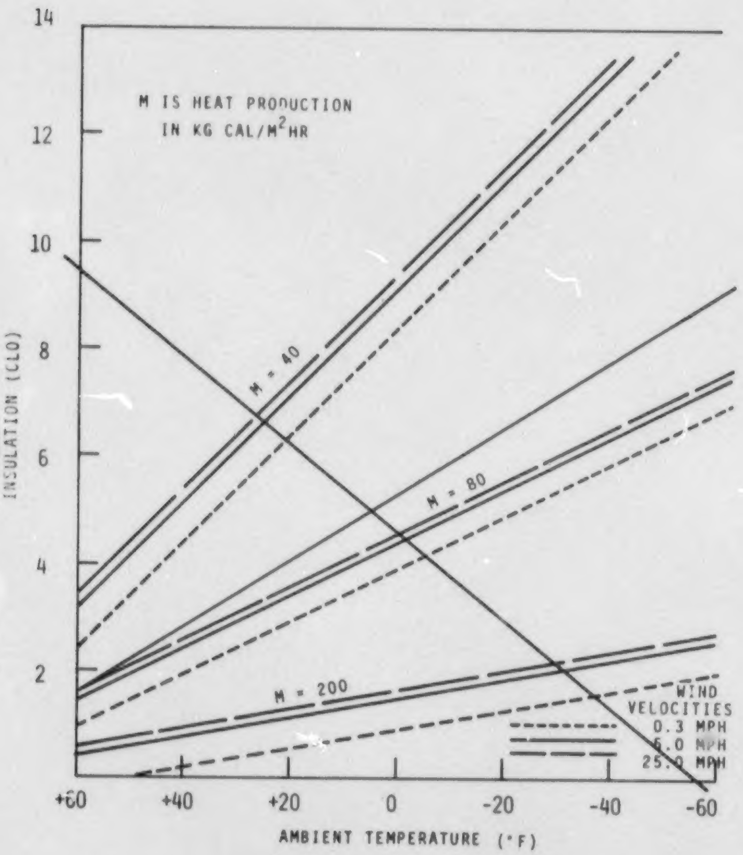

$\text{TEMPERATURE}_{\text{DRY BULB}}/\text{TEMPERATURE}_{\text{WET BULB}}$ CHART

FIGURE 2.9

Does Figure 2.10 now tell you why summer air cooling is important in Texas? To what extent is winter heating important?

OUTDOOR TDB/TWB CHART FOR REPRESENTATIVE TEXAS CITIES

	Higher Summer TDB			Lowest Winter TDB		Daily TDB Range	Highest TWB
	1	2	3	4	5	6	7
WICHITA FALLS	103/73°	101/73°	98/73°	14	18	24	75-77
DALLAS	102/75°	100/75°	97/75°	18	22	20	77-78
CORSICANA	100/75°	98/75°	96/75°	20	25	21	77-79
AUSTIN	100/74°	98/74°	97/74°	24	28	22	77-78
EL PASO	100/64°	98/64°	96/64°	20	24	27	68-69
SAN ANTONIO	99/72°	97/73°	96/73°	25	30	19	76-77
AMARILLO	98/67°	95/67°	93/67°	6	11	26	70-71
HOUSTON	97/77°	95/77°	93/77°	28	33	18	79-80
CORPUS CHRISTI	95/78°	94/78°	92/78°	31	35	19	79-80

All values in °F TDB/TWB except where indicated

1. Column 1, 2 and 3 give TDB/TWB for 1%, 2-1/2% and 5% of summer days. Only 1 day in 100 is column 1 exceeded; only on 2-1/2 days is Column 2 exceeded and so on.

2. Columns 4 and 5 give TDB for 99% and 97-1/2% of winter days. In 99% (97-1/2%) of winter days, these values are exceeded.

3. Column 6 shows the mean daily range in TDB. Thus, El Paso commonly experiences a TDB fluctuation of 27°F between the hottest hour during the day and the coldest hour during the night.

4. Column 7 shows TWB for the 15 days when the atmosphere was most humid in a recent 5 year period. Thus, Corpus Christi and Houston experience greater humidity than Amarillo and El Paso.

FIGURE 2.10

At this point, the student should be able to plot a comfort zone on a "psychometric chart" (psychro=humidity; metric=measurement). Such psychometric charts are important. They are used extensively by architects, HVAC engineers, and building managers.

Discuss the meaning of the psychrometric chart you have produced.

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

UNIT III

CONTROLLING BUILDINGS FOR THERMAL COMFORT

UNIT OBJECTIVES

1. List four reasons one might need to control the temperature, humidity, and air movement inside a building.
2. Explain why it is important to know the rate of occupancy and the duration of occupancy of a building.
3. Explain how the human body reacts to excess body heat storage.
4. Explain how excess body heat can be reduced.
5. List at least three important factors to consider when considering body heat production.
6. Explain why it may be more difficult to establish the proper temperature conditioning for a home than for a relatively large factory.

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

UNIT III

CONTROLLING BUILDINGS FOR THERMAL COMFORT

LECTURE

A. Occupany and Duration

The need to control the temperature, humidity, and air movement inside a building may vary. It may be for purposes of safety, odor removal, for the contents stored, or for human comfort. If the above factors are controlled comfort, there are two factors to be determined: (1) the rate of occupancy (how many persons will be inside); (2) the duration of occupancy (whether people typically remain in the building for just a few minutes at a time, for a period of one hour, or for a period of four hours or longer). Buildings such as sports arenas and churches are usually occupied by a large number of people for a short period of time. Additionally, such buildings may be occupied for only a few times each week.

In contrast, buildings such as schools or hospitals may be occupied by a large number of people for a long period of time during the greater part of each week. Therefore, different spaces have different thermal conditioning requirements according to occupancy and duration of stay. Because of this, the enclosed environment can be maintained at different comfort

ACTIVITIES

Discuss the occupancy of your school building. Was your classroom occupied at 8 a.m.? For how long? What was the number of occupants? What will be the school occupancy at 8 tonight? 8 p.m. on Saturday night during a social function? 8 p.m. next Sunday? Is there a difference between the occupancy of the entrance space, the classroom, the offices, and the kitchens?

index values for comfort. For example, in a classroom that is occupied by 30 students for 90 minutes the temperature will rise because of body heat production. Therefore, the room must be both cooled and ventilated. In contrast, however, 30 people may pass through an entrance hall of the same size during a period of 90 minutes. However, because of the short period of occupancy, there will be no need to cool or ventilate it to classroom comfort conditions.

Review the table at Figure 3.1. Which spaces or buildings are likely to be occupied continuously by the same person for three or more hours? Does the space then remain empty?

OCCUPANCY AND DURATION OF STAY IN BUILDING TYPES

	SPACE OR BUILDING	OCCUPANCY	DURATION OF STAY PER PERSON
1.	ENTRANCE LOBBIES	FEW AT A TIME	SHORT
2.	ELEVATORS	ONE OR SEVERAL	SHORT
3.	CONVENIENCE STORES	SEVERAL	MINUTES
4.	RESTAURANTS	VARIABLE	1/2 - 1 HOUR
5.	CLASSROOM	SUBSTANTIAL	3/4 - 1 1/2 HOURS
6.	LIBRARIES	SEVERAL OR MANY	VARIABLE
7.	CHURCHES	SUBSTANTIAL	1-2 HOURS
8.	SPORTS ARENAS	THOUSANDS	2-3 HOURS
9.	MOVIE THEATERS	HUNDERDS	2-4 HOURS
10.	OFFICES	FEW	8 HOURS
11.	MOTEL ROOM	ONE OR TWO	8 HOURS OR MORE
12.	HOSPITAL ROOM	ONE OR TWO	24 HOURS OR MORE

FIGURE 3.1

It should be noted that people readily adapt and feel comfortable in a wide range of temperatures if they plan to leave shortly or if they are simply passing through.

Preferred temperatures are usually measured for one-, two-, or three-hour periods by vote or by preferred thermostat settings. Average values are plotted as "comfort lines" on a graph of T_{DB} vs. T_{WB}. Refer now to Figure 3.2.

Do the graphs at Figure 3.2 show any difference between one-hour comfort and three-hour comfort for men? For women? Do women prefer a warmer temperature than men for one hour? If moist air is dehumidified by removing water or by mixing with dry outside air, is a warmer or cooler T_{DB} preferred? Note that a range of 30%-70% relative humidity (RH) is commonly accepted, but that RH will rise quickly in a well occupied classroom or other space. Why? Discuss the differences in occupancy and duration of use in your classroom? Are there any other factors which affect your comfort (i.e., air movement type of activities performed, number of occupants, time of day, if the period follows recess or lunch, etc.)

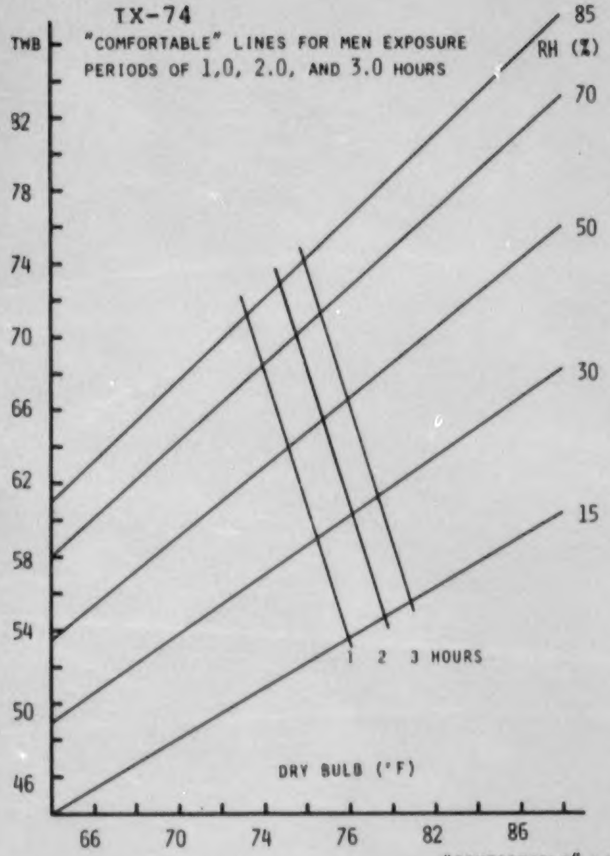


FIGURE 3.2a

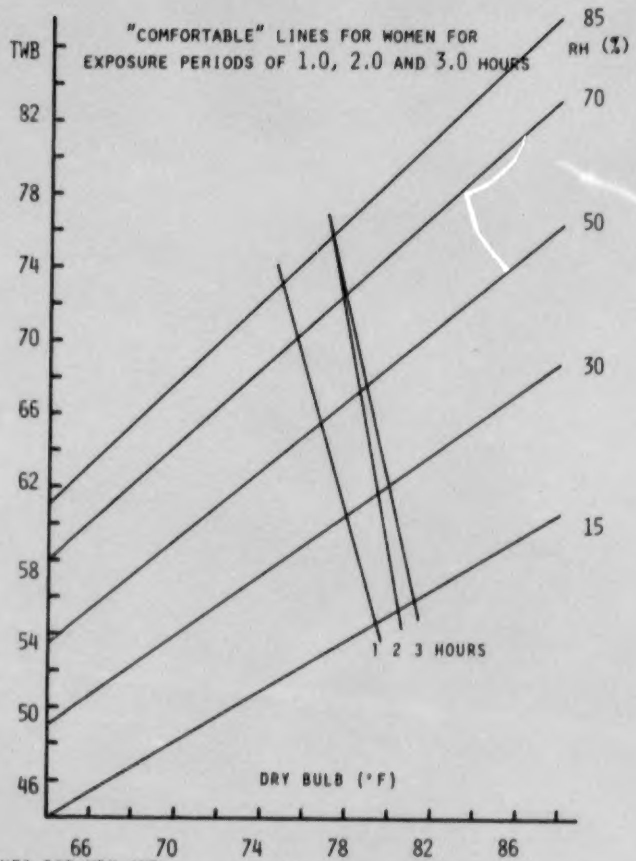


FIGURE 3.2b

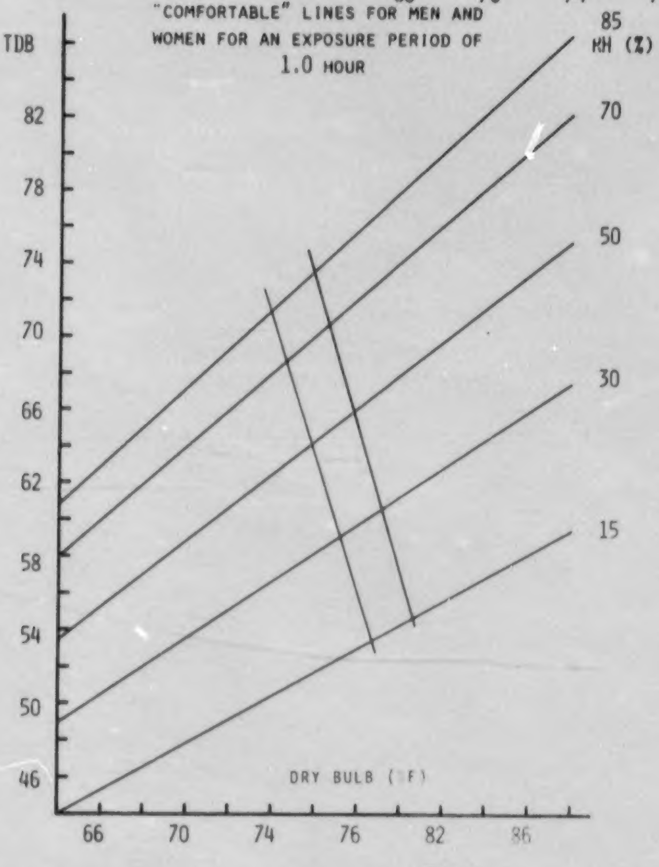


FIGURE 3.2c

B. Activity and clothing

In order to understand the conditions under which the human body remains in continued thermal comfort, we should examine the heat balance equation below:

BODY HEAT PRODUCTION = BODY HEAT LOSS TO SURROUNDINGS

Body heat production is increased by such activities as physical work or eating. Body heat loss is decreased by raising the temperature, reducing air movement, or by increasing the "clo" insulation value of garments worn. If any or all of these factors are brought into play, the heat balance equation is shifted temporarily to:

BODY HEAT PRODUCTION − BODY HEAT LOSS TO SURROUNDINGS
(minus)
=
(equals) BODY HEAT STORAGE

How does the body respond to heat storage? Initially, there is an increase in the breathing rate, a greater flow of blood to the skin and a feeling of warmth that may become uncomfortable. If body heat storage continues, the individual begins to breathe heavily, sweat, flush, and develop difficulty in paying attention.

This condition can, however, be reversed by-
(1) reducing heat production
(2) increasing convective
(3) increasing evaporate cooling
(4) reducing thermal insulation

Take body temperature measurements at rest, after mild activity, and after strenuous activity.

Plot temperature as a function of time, both during and after activity.

TABLE OF HEAT PRODUCTION RATES

	Typical values for BTU/hr
Asleep	
Sleeping, men over 40	260
Sleeping, men aged 30-40	280
Sleeping, men aged 20-30	280
Resting	
Lying moderately relaxed	320
Lying awake--after meals	340
Sitting at rest	400
Very light activity--seated	
Writing	430
Typing	550
Polishing	570
Very light activity--standing	
Relaxed	440
Typing	460
Polishing	480
Light activity--seated	
Playing musical instruments	690
Repairing boots and shoes	720
At lecture	730
Light activity--standing	
Washing clothes	610
Ironing	890
Scrubbing	1040
Light activity--moving	
Slow movement about room	600
Vehicle repair	820
Washing	1000
Moderate activity--sitting	
Rowing for pleasure	1190
Cycling at 8-11 mph	1360
Cycling rapidly	1640

FIGURE 3.3

	TYPICAL VALUES FOR BTU/HR
MODERATE ACTIVITY--STANDING	
GARDENING	1380
CHOPPING WOOD SLOWLY	1480
SHOVELING SAND SLOWLY	1620
MODERATE ACTIVITY--MOVING	
GOLF	1290
TABLE TENNIS	1380
TENNIS	1500
HEAVY ACTIVITY--LYING	
LEG EXERCISES, AVERAGE	1790
SWIMMING BREAST STROKE AT 1.6 MPH	1950
SWIMMING BACKSTROKE AT 1.0 MPH	1980
HEAVY ACTIVITY--SITTING	
CYCLING RAPIDLY--OWN PACE	1980
CYCLING AT 10 MPH--HEAVY BICYCLE	2120
CYCLING IN RACE 100 MI IN 4 HR., 22 MIN.	2340
HEAVY ACTIVITY--STANDING	
CHOPPING WOOD RAPIDLY	1790
SHOVELING SAND RAPIDLY	1830
SAWING WOOD BY HAND	1900
HEAVY ACTIVITY--MOVING	
SKATING AT 9 MPH	1860
SKIING AT 8 MPH ON LEVEL	2140
CLIMBING STAIRS AT 116 STEPS PER MINUTE	2340
VERY HEAVY ACTIVITY--SITTING	
CYCLING AT 13.2 MPH	2380
GALLOPING ON HORSEBACK	2720
SCULLING 97 STROKES/MIN.	3000

FIGURE 3.3 (CONT.)

Very heavy activity--moving	Typical values for BTU/hr
Fencing	2500
Playing basketball	2720
Climbing stairs	2860
Extreme activity	
Wrestling	3100
Marching at double	3160
Endurance marching	3520

Note:

BTU/hr is the rate of heat production per hour. These measurements are given for a person 69 inches tall and 167 pounds in absolute units.

SOURCE: JOHN FLETCHER, ENVIRONMENT, ENERGY AND SOCIETY, 1973.

FIGURE 3.3 (CONT.)

Heat production can be reduced by intermittent work, rest pauses, and/or slower work. Convective cooling, evaporative cooling and reduced thermal insulation can all be brought about by reducing the number of garments worn, by moving to a cooler area, or by fanning the air.

If people are exposed to prolonged periods of heat without compensation or treatment, the results will be dehydration, heat fatigue, loss of temperature, and finally death. Because of this, individuals who must suffer long periods of heat should be provided with chilled water for drinking as well as for wetting their skin.

During the hot summer months, most people wear fewer layers of clothing that is light in color and made of thin fabrics. Additionally, during the summer, more of the skin area is exposed to allow for more evaporative cooling.

Those activities associated with the least heat production include sleeping, lying, reclining, and sitting. During light work, however, heat production is more than doubled. During moderate activity, heat production may even be quadrupled. In athletes and people engaged in hard physical activities, heat production may be increased 10 to 20 times.

When considering body heat production, body size and sex are important factors to consider. Even when performing the same task, tall, heavy people produce more heat than short, light individuals. Figure 3.3 gives representative heat production rates for men and women in Btu/hr. These are individuals of typical North American stature and build.

When exercise ceases, heat production continues for various periods of time. However, it is not uncommon for heat production to continue for at least an hour after exercise has ceased.

How can heat balance be achieved during work? Obviously, heat loss must somehow be increased. This may be achieved by wearing fewer clothes or by reducing the T_{DB} and T_{WB} below resting comfort levels.

Just how much adjustment is needed to achieve heat balance? This depends upon the level of body heat production and/or the environmental conditions. For example, at 75°F, 50% R.H. (relative humidity), and 30 r.p.m. air movement, the table in Figure 3.4 applies.

Notice that Figure 3.4 shows that the required "clo" value at rest is twelve times greater than the "clo" value required during heavy work such as climbing stairs. Therefore, it should be obvious that careful attention should be given to the "clo" value of clothing during different types of work and other activities.

Rather than reducing the "clo" value during heavy work, would similar results be achieved by raising the air movement to 100 r.p.m. If so, why?

It is also important to realize that if the T_{DB} and T_{WB} are reduced excessively in over-cooled rooms or in the winter the body responses are:

(1) blanched skin and "goose bumps"
(2) shivering
(3) increased body heat production

These symtoms are then followed by:

(1) increased need for food
(2) T(skin) reduced below comfort level
(3) T(body) reduction and body chills
(4) colds and respiratory infections such pneumonia and influenza.

If the above conditions should continue for a long period, then excessive deaths will occur even among young adults and healthy outdoor workers. In freezing outdoor temperatures and windstorms, frostbite will occur unless heavy protective clothing ("clo" values; 2-4 units) is worn. In the Texas Panhandle, temperatures below 0°F and winter windstorms frequently cause severe body chilling during December and January. This is, of course, due in large part to the windchill factor.

Verify from Figures 3.3 and 3.4 that a person climbing stairs produces in ten minutes ten times as much heat for a few minutes as when sleeping or lying relaxed. Also, that a large female or average male produces 24%-30% more heat than a smaller person of the same size performing the same task.

HEAT LOSS

TYPICAL ACTIVITY	EVAPORATIVE HEAT LOSS	CLO FOR HEAT BALANCE
SLEEPING	53 BTU/HR.	0.6 LIGHT WINTER CLOTHING
SCRUBBING	226 BTU/HR.	0.14 T-SHIRT & BRIEFS, BRA & SHORTS
CLIMBING STAIRS	644 BTU/HR.	0.05 BRIEFS ONLY

FIGURE 3.4

C. Workplaces vs. homes

Workplaces are usually temperature-controlled for shift work as well as for the comfort of healthy workers between the ages of 16-65 years of age. Locations of heavy and light occupations are usually segregated and individually air-conditioned. Eight hours is the usual limit for the working day or shift. After that, occupancy changes. In each working area, temperature conditioning is usually adjusted to the clothing and activity levels of the workers. Because the workers in each area have similar comfort needs, it is not difficult to adjust heat balance to their satisfaction. However, special requirements can be met by zoning work places for special cooling, ventilation, screening, or warming.

By contrast, homes are the 24-hour, 7-day residences of heterogenous individuals ranging from babies of a few weeks to retired individuals well past 70 years of age. Additionally, some of the inhabitants are active while others are sedentary. Some are healthy while others are ill. Because of such variations, it is not uncommon to find that each member of a family has a different comfort zone.

In addition to individual needs for different comfort zones, various rooms (because of the nature of their function or use) will require different temperature conditioning. For example, in bedrooms where 8-hour sleeping periods of low heat production is the usual activity, the comfort zone is different from that of the garage, workshop, home laundry, kitchen or playroom.

Record temperatures for 24 hours in typical homes of different construction, with and without air conditioning. Make a graph of temperature vs. time for this 24-hour period.

Observe and record the number of residents at home and the type of air conditioning or ventilation in use, if any.

Compare the graphic highs and lows in the different locations and relate them to the activities of occupants. Repeat this activity for typical workplaces, such as a large office, a machine shop, a power plant, or a warehouse.

In multifamily houses there is greater use of control temperature conditioning as well as humidity control. As a result, the indoor climate of these dwellings is usually more nearly uniform than in smaller houses.

In studying the temperature conditioning needs of a house, it is important to examine the night and day temperature fluctuations of various areas. This can best be accomplished using 24-hour or 7-day thermographs. The use of several thermographs in different parts of the same house will better show the cycling effect of cool/night and warm/day conditions. The effects are most marked in open areas. Additionally, seasonal changes are also seen to be very marked in such locations.

As one might suspect, substantial temperature cycles are commonly found in non-conditioned or poorly insulated homes. Such fluctuations present additional problems in areas of high utility rates because of added expenses.

There are two problems that remain to be examined. First, the temperature-control mechanisms of the body are poorly developed in young children, and sometimes are impaired in older people. It is not uncommon for both groups to be unable to operate thermostats or windows for their personal comfort. Because body chilling and overheating is more likely to occur in such individuals, attention and assistance must be given both groups.

The second problem encountered is individual differences in size, body build, activity level, and mobility. This alone makes it difficult to achieve satisfactory home air conditioning.

During summer months in Texas, an increase is seen in deaths related to extreme heat. In what age group would you suppose most would occur? What problems and illnesses would be susceptible to heat? What steps, if any, could be used to prevent collapse and death.

D. Energy-Saving Options

Active controls such as thermostats are devices which activate heating, ventilating, or cooling systems at constant power and then cut off when the set temperature point has been achieved.

Passive controls such as switches are those operated at the option of users. If left in the minimum load or OFF position until needed, and if turned ON as soon as comfort levels are inadequate, such controls are energy-saving. Time controls, such as those which activate heating lamps and other devices for a limited period, are also energy-saving devices used in comfort conditioning. With the rise in utility and fuel costs in Texas in the period 1972-80 (electricity: 2.51¢ to 6.20¢ per kilowatt hour; natural gas: 25¢ to $3.03 per thousand cubic feet in typical areas) the available options for energy-saving include:

1. Retain comfort control settings and pay the increased prices according to variations in climate.
2. Adjust comfort control settings to operate at higher summer temperatures and lower winter temperatures within the broadrange of the comfort zone.
3. Install time controls or passive controls in such a way that heating, ventilating and air conditioning equipment will run only when buildings are occupied.
4. Convert from high cost/low efficiency equipment to low cost/high efficiency HVAC equipment for ventilation, cooling, and heating.

5. Eliminate use of air conditioning for all months in which outside temperatures are within the comfort zone.

6. Adjust air conditioning (cooling and heating) to compensate for internal heat gains from the number of people, lighting, cooking, and related factors.

7. Increase air movement for evaporation and convective cooling by using ceiling fans, pedestal fans, and natural ventilation.

8. Adjust clothing insulation daily to conserve heat when cool, and increase heat loss when hot.

9. Introduce single-room, zone, or spot air conditioning or ventilating in place of total air conditioning.

10. Maximize the benefit of natural seasonal acclimatization by adopting seasonal clothing styles/types and by repeated daily open-air exposure.

11. Utilize existing architectural and construction features which will maximize the utility of natural ventilation, shade and evaporative cooling in summer, and solar heating in winter, and reduce unwanted cold-night/hot-day cycling.

12. Develop future architectural and construction features which will maximize the utility of natural ventilation, shade and evaporative cooling in summer, and solar heating in winter, and reduce unwanted cold-night/hot-day cycling.

Discuss the feasibility and importance of items (1) to (12). Discuss tradeoffs which can be used to accomplish energy conservation.

SUMMARY

Many options exist for improving thermal comfort passively and by changed behavioral patterns. Human comfort is affected by many variables, both energy-using and energy-conserving. Tradeoffs exist between the acceptance of hour- to-hour, day-to-day, and season-to-season changes in temperature within the comfort zone, and the use of energy to control temperature to narrow these limits. Energy conservation and cost savings in buildings are achieved by greater attention to variable levels of tradeoffs, with natural climate and human adaptability as important variable components.

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

POSTTEST

DIRECTIONS: Circle the correct answer.

1. The human body contains thermal energy.

   a. true b. false

2. Thermal energy and heat are not the same things.

   a. true b. false

3. The total thermal heat of a body is measured by units called:

   a. "clos"
   b. microns
   c. Btu
   d. degrees

4. Fats and other foods are sources of thermal energy for human beings.

   a. true b. false

5. Young invididuals usually require more calories than older individuals.

   a. true b. false

6. Fatty tissue is a result of:

   a. excessive heat
   b. lack of heat
   c. excessive calories
   d. none of the above

7. Molecular collisions result in:

   a. molecular distortion
   b. heat
   c. electron transfer

8. The greater the rate of air moving across the surface of the body, the greater the cooling effect.

   a. true b. false

9. The human body cannot compensate for temperature changes.

   a. true b. false

10. The lower the "clo" value, the better the insulation quality of clothing.

    a. true b. false

11. Cooling of your body through the evaporation of water from your skin is important.

    a. true b. false

12. Only the T_{WB} is necessary to determine the RA.

    a. true b. false

13. Air above your skin does not act as an insulator.

    a. true b. false

14. The Globe thermometer is used to measure only radiant energy.

    a. true b. false

15. People are always comfortable when the relative humidity is low.

    a. true b. false

16. The rate of occupancy is just one of the several factors one should consider when controlling the temperature of a building.

    a. true b. false

17. Excessive body heat can be eliminated.

    a. true b. false

18. It is not important to consider the variations in the age and sex of individuals when controlling the temperature of a house.

    a. true b. false

MODULE IX

HUMAN COMFORT AND ENERGY CONSERVATION

ANSWERS TO POSTTEST

1. a. true
2. a. true
3. c. Btu
4. a. true
5. a. true
6. c. excessive calories
7. b. heat
8. a. true
9. b. false
10. b. false
11. a. true
12. b. false
13. b. false
14. b. false
15. b. false
16. a. true
17. a. true
18. b. false

BODY TEMPERATURE CHART

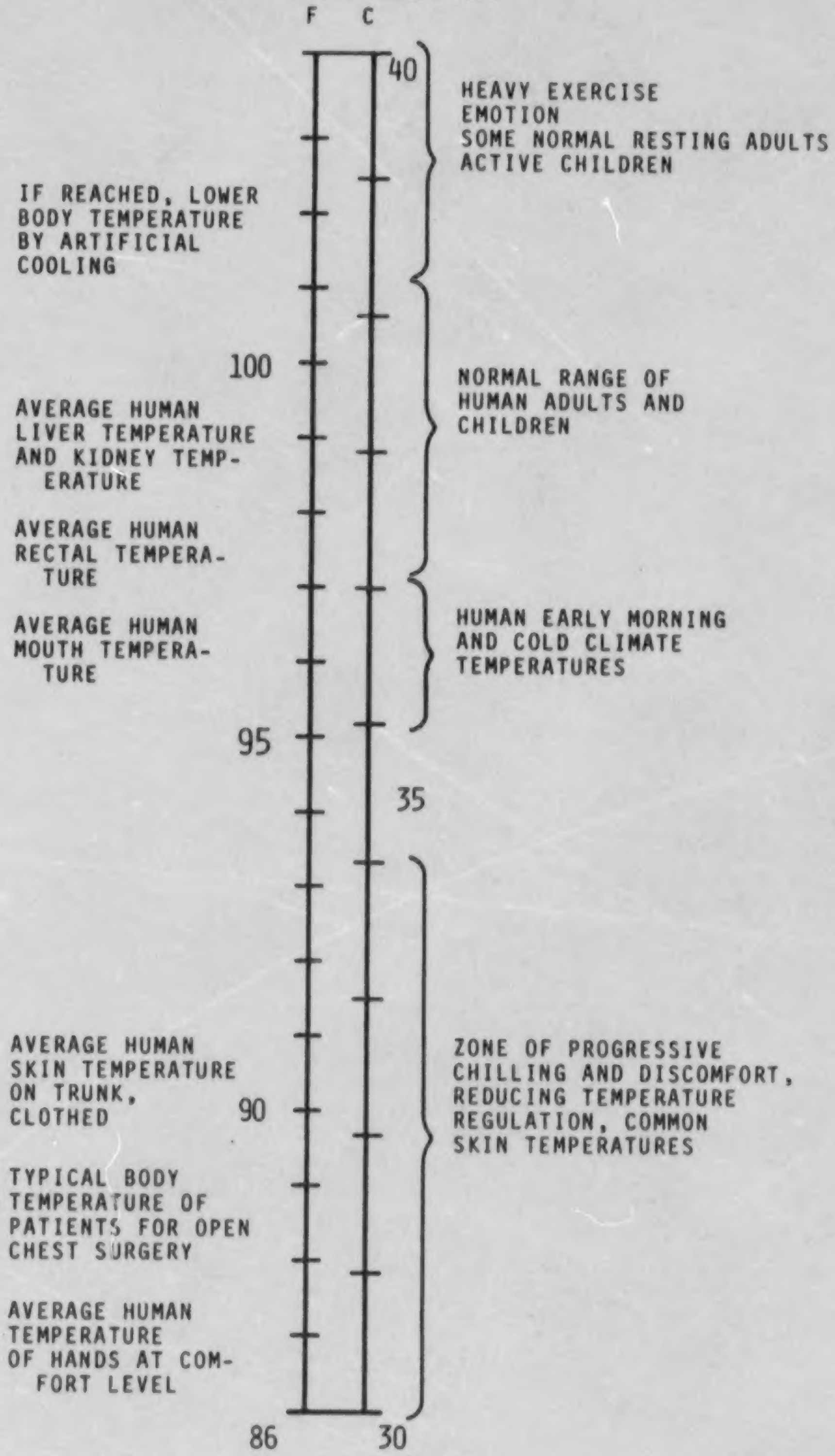


FIGURE 1.1

COMPENSATORY RESPONSES

	THERMAL SURROUNDINGS	HEAT PRODUCTION CHANGE
1	COLD AIR WINTER SEASON COLD CLIMATES	INCREASED PHYSICAL ACTIVITY INCREASED FOOD INTAKE DECREASED FLUID INTAKE AND SWEATING
2	HOT AIR SUMMER SEASON HOT CLIMATE	DECREASED PHYSICAL ACTIVITY DECREASED FOOD INTAKE INCREASED FLUID INTAKE AND SWEATING

COMPENSATION IS OVER A PERIOD OF TIME AND IS PARTLY VOLUNTARY.

FIGURE 1.2

ADJUSTMENTS TO SKIN HEAT LOSS

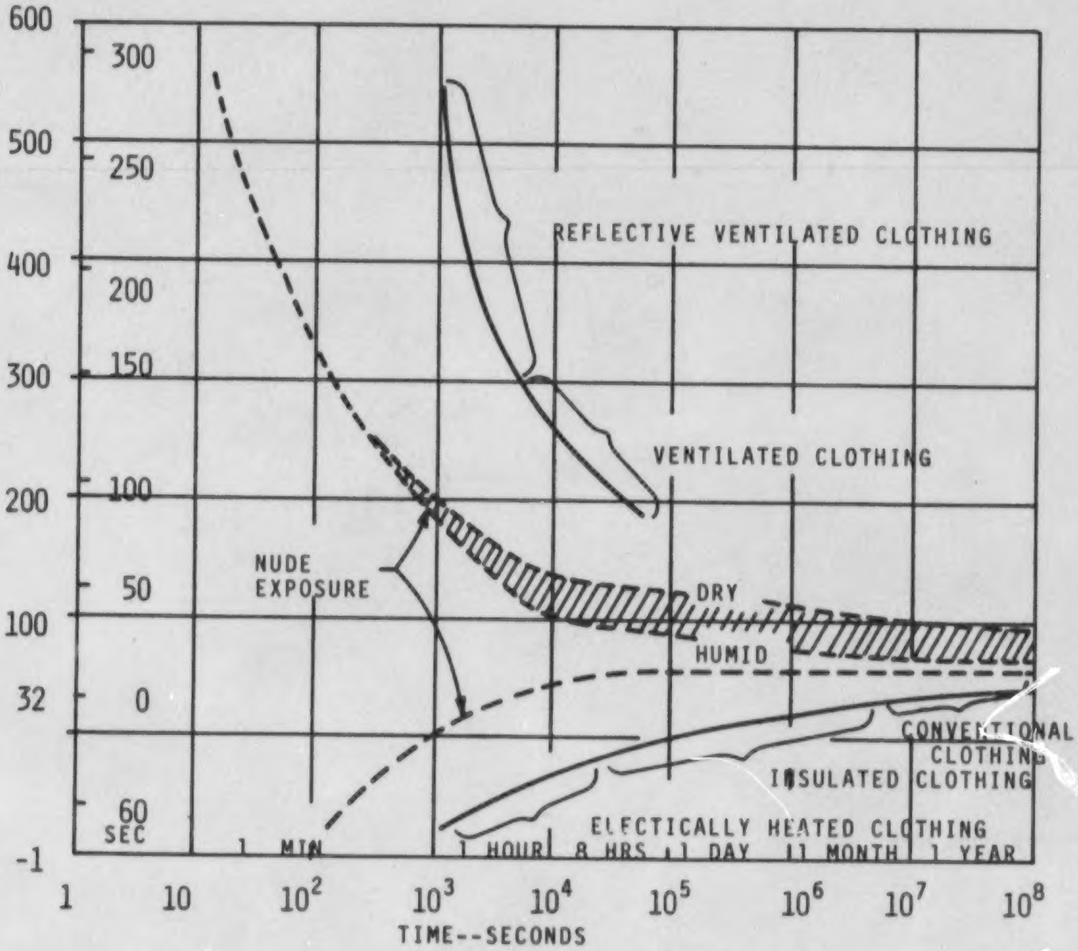
	THERMAL SURROUNDINGS	SKIN-BLOOD FLOW CHARGE
1	COLD AIR LOW THERMOSTAT SETPOINT LOW SURFACE TEMPERATURES	BLANCHES SKIN, REDUCED BLOOD FLOW, LIMITED SWEATING, SHIVERING; INCREASED HEAT PRODUCTION
2	HOT AIR HIGH THERMOSTAT SETPOINT HIGH SURFACE TEMPERATURES	PINK SKIN, INCREASED BLOOD FLOW SWEAT RATE RAISES; INCREASED HEAT LOSS; AREA OF MOIST SKIN INCREASED

ADJUSTMENTS ARE RAPID AND CONTROLLED BY NERVOUS REFLEX.

FIGURE 1.3

TEMPERATURE-TIME SURVIVAL CHART

THE MAN-MADE ENVIRONMENT-TEMPERATURES FOR HUMAN SURVIVAL IN AIR



SOURCE: JOHN FLETCHER, ENVIRONMENT, ENERGY AND SOCIETY, 1973.

FIGURE 1.4

COMFORT SCORE GUIDE

THE DESCRIPTIONS BELOW REPRESENT THE GRADUATING SCALE FOR INDICATING DEGREES OF COMFORT.

1. COLD
2. COOL
3. SLIGHTLY COOL
4. COMFORTABLE
5. SLIGHTY WARM
6. WARM
7. HOT

FIGURE 1.5

CLOTHING ENSEMBLE CLO VALUES

	AN AVERAGE OF 12 SEDENTARY INDOOR CLOTHING ENSEMBLES.	LIGHT, SUMMER, SUB TOPICAL.	HEAVY, WINTER, NORTHERN USA.
MEN	0.76	0.38	1.18
WOMEN	0.74	0.27	1.20

(ALL VALUES IN CLO UNITS)

SOURCE: JOHN FLETCHER, ENVIRONMENT, ENERGY AND SOCIETY, 1973

FIGURE 1.6

INDIVIDUAL GARMENTS: INSULATION IN CLO UNITS

INSULATION VALUE*	ITEM
0.01	PANTIHOSE
0.02	SANDALS
0.03	COOL SOCKS
0.04	SHOES GIRDLE
0.05	BRIEFS BRAS & PANTIES
0.06	UNDERSHIRT MINI-SKIRT
0.09	T-SHIRT SUMMER SHIRT
0.14	COOL L.S. KNIT SHIRT HALF SLIP
0.19	WOVEN S.S. SHIRT SUMMER BLOUSE
0.26	SUMMER TROUSERS
0.29	WOVEN L.S. SHIRT L.S. BLOUSE
0.32	WARM TROUSERS
0.37	L.S. WINTER SWEATER
0.49	WARM JACKET
0.63	WARM DRESS

* CLO VALUES ARE ADDED FOR EACH GARMENT WORN IN AN ENSEMBLE TO OBTAIN OVERALL CLOTHING INSULATION.

SOURCE: JOHN FLETCHER, ENVIRONMENT, ENERGY AND SOCIETY, 1973.

FIGURE 1.7

CLOTHING MATERIAL CHARACTERISTICS

	Cotton	Linen	Wool	Silk	Acetate	Triacetate	Acrylic Modacrylic	Nylon	Olefin	Polyester	Rayon
Absorbency	+	+	+	+	-	-		-		-	+
Appearance & Hand				+	+	+	+				+
Colorfastness	+	+	+	+	-		+	+		+	+
Dimensional stability		+		+	+	+	+/-	+		+	-
Drapability				+	+	+					+
Durability		+									
Dyeability	+		+	+					-		+
Elasticity								+			
Laundrability	+										
Pressed-in crease retention	-	-	+	-	-		+			+	
Resiliency			+				+	+		+	-

FIGURE 1.8

	COTTON	LINEN	WOOL	SILK	ACETATE	TRIACETATE	ACRYLIC MODACRYLIC	NYLON	OLEFIN	POLYESTER	RAYON
RESISTANCE:											
ABRASION		-		-	-	-	-	+	+	+	-
AGEING				-					+		
CHEMICALS			-				+		+		
FRICTION			-								
HEAT	+	+		-		+					
MILDEW	-	-			+		+	+		+	-
MOTHS	+	+	-		+		+	+	+	+	
PERSPIRATION	+	+	-	-				+	+	+	
PILLING			-				-	-	+		
STAINS									+	-	
SUNLIGHT	-	-	+	-			+	-	+	+	
WEATHER									+	-	
WRINKLING	-	-	+	+	-	+	+	-	+	+	-
SOFTNESS	+						+				-
STRENGTH											
WET	+			-	-	-	-	+		+	
DRY	+			+	-	-	-	+		+	
WARMTH			+				+			+	
WASH & WEAR QUALITY	-		-		-	+	+			+	-
WATER REPELLENCY			-								

SOURCE: "FIBERS AND FABRICS", CONSUMER GUIDE FROM THE NATIONAL BUREAU OF STANDARDS

+ =GOOD TO EXCELLENT
- =FAIR TO POOR

FIGURE 1.8 (CONT.)

APPROXIMATE CALORIC VALUES OF SOME COMMON FOODS

CALORIC VALUES ARE GIVEN IN NUMBERS THAT ARE MULTIPLES OF FIVE TO SIMPLIFY THE ESTIMATING OF TOTAL CALORIES.

FOOD	SIZE OF SERVING	APPROXIMATE CALORIES
FOODS CLASSED AS LARGELY CARBOHYDRATES:		
APPLES, RAW	1 MEDIUM	75
APPLE PIE	1/6 MEDIUM PIE	400
APPLE SAUCE	1/2 CUP	95
APRICOTS, CANNED	3-4 AND 2 T. JUICE	75
APRICOTS, FRESH	2-3	55
APRICOTS, DRIED	4-6 HALVES	100
ASPARAGUS, RAW	8-12 STALKS 5"	25
ASPARAGUS, CREAMED	1/4 CUP	100
BANANAS, FRESH	1 MEDIUM	100
BEANS, STRING, FRESH	1 CUP	25
BEETS, SLICED, FRESH	1 CUP	65
BISCUITS, BAKING POWDER	1 MEDIUM	100
BLACKBERRIES, FRESH	1/2 CUP	40
BLANC MANGE, CHOCOLATE	1/2 CUP	220
BLANC MANGE, PLAIN	1/2 CUP	150
BREAD, WHOLE WHEAT	1 SLICE, 1/2"	55
BREAD, WHITE ENRICHED	1 SLICE, 1/2"	60
BREAD, WHITE, RAISIN	1 SLICE, 1/2"	65
CABBAGE, RAW	1 1/4 CUP	30
CAKE, ANGEL	PIECE 3" CIRCUMFERENCE	140
CAKE, CUP, PLAIN	1 MEDIUM	200
CAKE, PLAIN	PIECE 2" x 1"	110
CAKE, SPONGE, HOT WATER	PIECE 3" CIRCUMFERENCE	155
CANTALOUPE	1/2 MEDIUM	45
CARBONATED BEVERAGES	6 OUNCES	80
CARROTS, RAW	2, 4" LONG	40
CARROTS, STEAMED, CUBED	1/2 CUP	20

FIGURE 1.9

CAULIFLOWER, STEAMED	1 CUP	30
CAULIFLOWER, RAW	1 CUP	25
CELERY	3/4 CUP OR 4 STALKS	20
CHERRIES, SOUR, FRESH, STONED	1 CUP	65
CHERRIES, SWEET, FRESH, STONED	1 CUP	65
CHOCOLATE, BITTER	1 SQUARE	140
CHOCOLATE CREAM MINT	1	50
CHOCOLATE FUDGE	PIECE 1 1/2" x 1" x 3/4"	100
COCOA, POWDERED	1 T.	20
COCONUT, PREPARED	1/3 CUP	115
CORN, CANNED	1/3 CUP	60
CORN, GREEN	1 MEDIUM EAR	85
CORN SYRUP	1/2 CUP	470
CORNFLAKES	1 CUP	50
CORNMEAL, COOKED	2/3 CUP	80
CORNMEAL, RAW	1/4 CUP	130
CORNSTARCH	1 T.	35
CRACKERS, GRAHAM	1	35
CRACKERS, SODA	1	30
CRANBERRY JELLY	2 T.	100
CREAM PIES WITH MERINGUE	1/6 MEDIUM PIE	300
CUCUMBER, FRESH	1/2 CUP OR 1 SMALL	15
DATES, UNSTONED	3-4	85
DOUGHNUTS	1	170
FIGS, DRIED	2 LARGE	100
FLOUR, WHEAT, WHITE, ENRICHED	1 CUP	405
FLOUR, WHOLE WHEAT	1 CUP	400
FRUIT COCKTAIL	3/8 CUP	100
GRAPEFRUIT	1/2 LARGE	100
GRAPENUTS	1/3 CUP	100
GRAPES, CONCORD, DELAWARE	SMALL BUNCH	80
GRAPES, MALAGA, TOKAY	SMALL BUNCH	75
GRIDDLE CAKES	1 CAKE 4" DIAMETER	80
HOMINY GRITS, COOKED	1 CUP	25
HONEY, STRAINED	1 T.	15
LEMON JUICE	1/2 CUP	10
LEMONS	1 MEDIUM	25
LETTUCE	1/4 LARGE HEAD	20

FIGURE 1.9 (CONT)

SUGAR, POWDERED	1 T.	30
SUNDAE, VANILLA ICE CREAM WITH CHOCOLATE SAUCE	1/2 CUP	220
TAPIOCA, CREAM	1/2 CUP	190
TOMATO JUICE	1/2 CUP	25
TOMATOES, CANNED	1/2 CUP	25
TOMATOES, FRESH	1 MEDIUM	30
TURNIP GREENS, COOKED	1/2 CUP	20
TURNIPS, COOKED	1/2 CUP	20
WAFFLES	1, 6" DIAMETER	215
WATERMELON	PIECE 2 1/2" x 2" x 3"	85
WHEAT, SHREDDED	1 LARGE BISCUIT	100
YEAST, COMPRESSED	1 CAKE	25
FOODS CLASSED AS LARGELY PROTEIN:		
ALMONDS, CHOCOLATE	5	105
ALMONDS, SALTED	10-12	95
BEANS, BAKED	1/2 CUP	100
BEANS, LIMA, COOKED	1/3 CUP	100
BEANS, NAVY, COOKED	1/2 CUP	105
BEEF, HAMBURG STEAK, BROILED	CAKE, 2 1/3" DIAMETER, 1/2" THICK	120
BEEF, ROUND, BROILED	PIECE 2 1/2" x 3" x 1/2"	125
BEEF, SIRLOIN STEAK, LEAN, BROILED	PIECE 4" x 3" x 3/4"	350
BUTTERMILK	1 CUP	85
CHEESE, AMERICAN	1" CUBE	115
CHEESE, COTTAGE	1/3 CUP	75
CHICKEN, LEAN MEAT, COOKED	3 SLICES 3 1/2" x 2 1/2" x 1/4"	115
CHOCOLATE BEVERAGE MADE WITH MILK	3/4 CUP	210
EGGS, SCRAMBLED	1/2 CUP	180
EGGS, WHOLE	1	75
FISH, LEAN, BROILED	PIECE 4" x 2 1/4" x 2/3"	125
GELATIN, GRANULATED	1 T.	35
HAM, BAKED	PIECE 4" x 2 1/2" x 3/4"	280
HAM, BOILED	1 OZ.	85
ICE CREAM, VANILLA	1/3 CUP	150
GELATIN DESSERT	1/3 CUP	75
JUNKET, PLAIN	1/2 CUP	115

FIGURE 1.9 (CONT)

Lamb chop, broiled	1	250
Lamb roast	slice 3 1/2" x 4 1/2" x 1/8"	200
Liver, raw	piece 4" x 3" x 5/8"	130
Milk, skimmed	1 cup	85
Milk, whole	1 cup	165
Oysters, raw	1/3 cup or 3 1/2 large	70
Pork chop, broiled	1 medium	250
Salmon, canned	1/2 cup	205
Soda water with vanilla ice cream	2/3 glass	200
Soup, cream of pea	1/2 cup	135
Soup, cream of tomato	1/2 cup	125
Walnuts, English	10 meats or 1 1/2 T. chopped	100
Foods classed as largely fat:		
Bacon, cooked	2 slices	100
Butter	1 T.	100
Cod liver oil	1 T.	100
Cottonseed oil	1 T.	125
Cream, 40%	1/2 cup	440
Cream, 18%	1/2 cup	245
French salad dressing	1/2 cup	470
Lard	1 T.	125
Mayonnaise dressing	1 T.	90
Oleomargarine, fortified	1 T.	110
Olives, green, unstoned	3-4	50
Olive oil	1 T.	135
Peanut butter	1 T.	90
Peanuts, shelled, roasted	9-10	50
Russian salad dressing	1 T.	100

FIGURE 1.9 (CONT)

Macaroni, cooked	1/2 cup	230
Maple syrup	1 T.	50
Mince pie	1/6 medium pie	455
Muffins, plain	1 medium	115
Oats, rolled, cooked	2/3 cup	100
Onions, raw	1 small or 3 T.	10
Orange juice	1/2 cup	55
Oranges	1 medium	50
Parsnips, cooked	1 medium or 1 cup	95
Peaches, canned	1 halves, 3 T. juice	85
Peaches, fresh	1 medium	50
Peaches, dried	4 medium halves	145
Pears, canned	2 halves, 2 T. juice	80
Pears, fresh	1 medium	70
Peas, canned	1/2 cup	55
Peas, dried, raw	2 T.	85
Peas, green, shelled	3/4 cup	75
Pineapple, canned	1 slice, 3 T. juice or 1 1/2 cups shredded	90
Pineapple, fresh	1 cup	74
Potatoes, sweet, baked	1/2 medium	100
Potatoes, white, raw	1 medium	100
Potatoes, white, creamed	1/2 cup	150
Prunes, dried	4 medium	75
Prunes, stewed	3 medium and 2 T. juice	100
Raisins, dried seeded	3/4 cup	320
Raspberries, fresh	3/4 cup	75
Rhubarb, fresh	1 cup	20
Rice, steamed	1 cup	200
Rice pudding, creamy	1/2 cup	110
Rolls, yeast	1 medium	120
Salad, chicken	1/2 cup	235
Salad, tomato, lettuce	1 serving	100
Sauce, white medium	1/4 cup	110
Spinach, cooked	1/2 cup	25
Squash, Hubbard, cooked	1/2 cup	50
Strawberries, fresh	3/4 cup	40
Sugar, brown	1 T.	50
Sugar, granulated	1 T.	50

FIGURE 1.9 (CONT)

MAXIMUM AND MINIMUM TEMPERATURES

MEAN TEMPERATURE*		MAX. F	MIN. F	RANGE F
TSK	(COMFORT)	95°	91°	4°
TDB	(COMFORT)	93°	72°	19°
TSK	(OUTDOORS)	100°	75°	25°
TDB	(OUTDOORS-TEXAS)	98°	20°	78°
TDB	(OUTDOORS-CONTINENTAL USA)	105	-3	108
T (SURF)	(OUTDOORS-** TEXAS)	139°	6°	133°
T (SURF)	(OUTDOORS-** CONTINENTAL USA)	168°	NA	NA

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*INDIVIDUAL REACTIONS TO TEMPERATURE MAY VARY SUBSTANTIALLY. THE MEAN TSK IS USUALLY THE AVERAGE SKIN TEMPERATURE FOR FEET, LOWER AND UPPER LEG, TRUNK, ARMS, HANDS AND HEAD. HOWEVER, THE FEET AND LEG TEMPERATURES ARE USUALLY MUCH MORE VARIABLE THAN THE TRUNK AND HEAD TSK. OUTDOOR TDB ARE AVERAGE MONTHLY AIR TEMPERATURES FOR JULY AND JANUARY (MAX.°F AND MIN.°F, RESPECTIVELY). MEAN T (SURF) OUTDOORS IS THE MEAN OF SHADE AND EXPOSED GROUND TEMPERATURES AND SKY TEMPERATURE AND SURFACE TEMPERATURE OF NEARBY OBJECTS.

** ESTIMATED 1-HOUR AVERAGES ON LIGHT SURFACES. COMPUTER MODELS FOR DARK SURFACES PREDICT OCCASIONAL VALUES AS HIGH AS 198°F OR ONE HOUR.

FIGURE 2.1

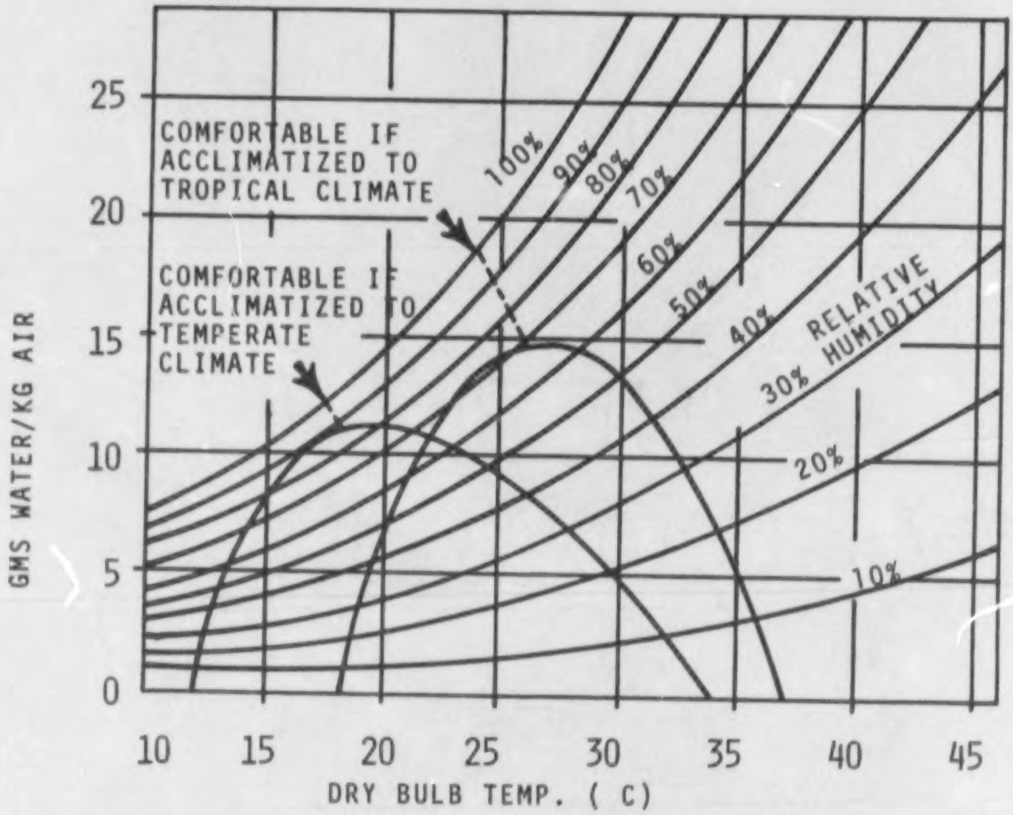
ACTIVITY

Time	TDB	Closed Container	TWB	Open Container
Before Starting fan	Same as air temperature	HOT (T HOT)	SAME AS AIR TEMPERATURE	HOT (T HOT)
After 5 minutes	AS ABOVE	STILL HOT	DROPS	SOMEWHAT COOLER
After 30 minutes	AS ABOVE	SOMEWHAT COOLER	NO FURTHER CHANGE*	COOLER THAN CLOSED CONTAINER
After 60 minutes	AS ABOVE		NO FURTHER CHANGE*	MUCH COOLER

*If the wick is allowed to go dry, note that TWB will rise until TWB = TDB. Confirm this. Keep the wick moist for accurate TWB readings.

FIGURE 2.2

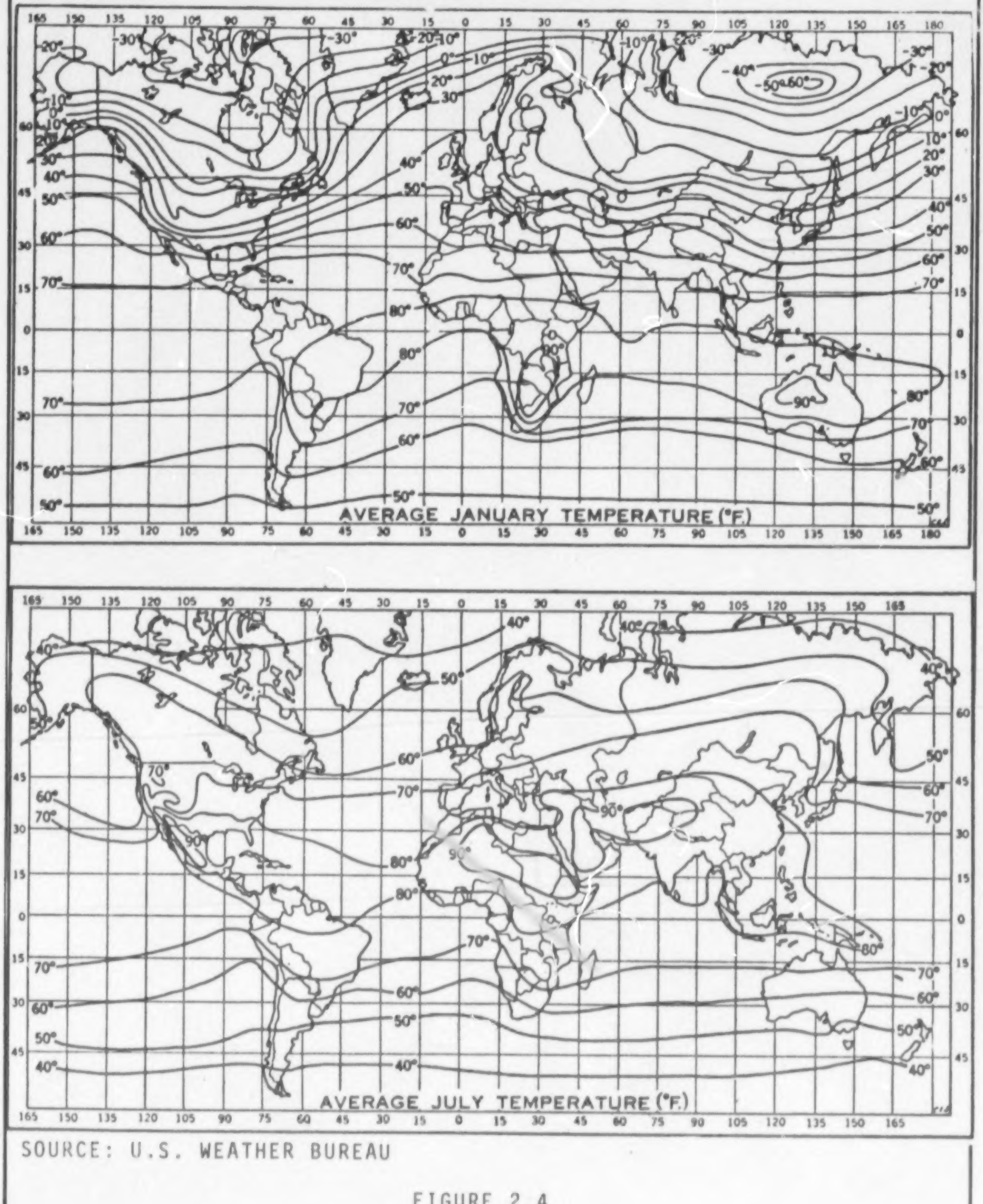
TEMPERATURE--HUMIDITY--COMFORT RELATIONSHIPS



SOURCE: JOHN FLETCHER, ENVIRONMENT, ENERGY AND SOCIETY, 1973.

FIGURE 2.3

WORLD ISOTHERM MAPS--JANUARY AND JULY


AVERAGE JANUARY TEMPERATURE (°F.)
165 150 135 120 105 90 75 60 45 30 15 0 15 30 45 60 75 90 105 120 135 150 165 180
-30° -20° -10° 0° 10° 20° 30° 40° 50° 60° 70° 80° 90°
-40° -50° -60°
AVERAGE JULY TEMPERATURE (°F.)
165 150 135 120 105 90 75 60 45 30 15 0 15 30 45 60 75 90 105 120 135 150 165
40° 50° 60° 70° 80° 90°

SOURCE: U.S. WEATHER BUREAU

FIGURE 2.4

CLIMATOLOGICAL AVERAGES AND EXTREMES

	TEMPERATURE (°F)				PRECIPITATION (INCHES)												
	A	B	C	D	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
ABILENE	94	33	111	- 9	.88	1.09	[illegible]	2.27	4.33	2.67	2.28	1.47	2.07	2.85	1.11	1.26	23.32
AMARILLO	92	21	108	-16	.65	.62	.82	1.32	3.37	2.89	2.34	2.58	1.89	1.76	.66	.77	19.67
ANGLETON	91	46	105	10	3.63	[illegible]	[illegible]	3.20	3.90	3.51	5.53	4.82	5.44	3.80	3.70	4.61	49.16
AUSTIN	95	41	109	- 2	[illegible]	2.58	2.13	[illegible]	3.71	3.22	2.18	1.94	3.44	2.83	2.12	2.53	32.58
BAY CITY	93	43	106	11	3.00	3.03	2.17	2.91	4.32	4.20	3.34	4.83	5.83	3.65	3.09	3.47	43.84
BEAUMONT	93	44	108	4	4.57	4.38	2.82	4.43	4.79	4.75	5.71	5.34	5.30	3.19	4.54	4.95	54.77
BEEVILLE	95	45	111	5	2.08	1.76	1.78	2.44	[illegible]	[illegible]	2.87	2.20	3.64	2.48	1.90	2.23	29.61
BRENHAM	95	43	111	- 2	3.22	3.11	2.74	3.58	4.18	3.29	2.88	2.88	2.88	2.86	3.81	3.89	39.12
BROWNSVILLE	93	52	104	12	1.36	1.31	1.07	1.37	2.55	2.63	1.73	2.54	5.51	3.22	1.78	1.55	26.65
CLEBURNE	96	35	114	- 3	2.04	2.64	2.35	3.79	4.46	2.92	2.17	2.25	2.78	2.94	2.28	2.58	33.20
CORPUS CHRISTI	94	47	105	11	1.63	1.70	1.44	2.14	2.99	2.39	2.32	2.77	4.40	2.76	1.72	2.08	28.34
CORSICANA	96	36	113	- 7	2.86	3.00	2.88	4.32	4.98	3.12	1.90	2.19	2.67	2.96	2.97	3.21	37.06
DALLAS	95	36	111	- 3	2.32	2.55	2.85	4.00	4.83	3.24	1.94	1.93	2.82	2.70	2.70	2.67	34.55
DENISON DAM	95	31	109	2	1.62	2.62	2.53	4.65	4.77	3.88	2.81	2.49	3.92	2.81	2.55	2.22	36.87
DENTON	96	34	113	- 3	1.90	2.42	2.51	3.69	5.03	3.16	2.05	1.73	2.37	2.46	2.05	2.19	31.56
DUMAS	93	20	109	-18	.60	.54	.78	1.30	2.95	2.45	2.60	2.62	1.55	1.60	.64	.70	18.33
EL PASO	94	32	109	- 8	.46	.41	.35	.29	.40	.69	1.29	1.19	1.14	.85	.33	.49	7.89
FORT WORTH	96	35	112	- 8	2.04	2.24	2.51	3.60	4.59	2.98	1.75	1.68	2.54	2.59	2.46	2.35	31.33
GAINESVILLE	96	32	114	-12	2.07	2.51	2.64	3.75	5.09	3.79	2.38	2.45	2.63	2.91	2.09	2.23	34.54
GALVESTON	87	42	101	8	3.46	2.88	2.86	2.59	2.79	2.65	4.79	4.39	5.09	2.86	3.56	3.89	41.81
GONZALES	96	42	106	18	2.15	2.32	1.96	3.55	3.71	2.91	2.79	2.43	3.54	2.42	2.42	2.53	32.73
GREENVILLE	94	34	116	- 4	2.89	3.31	3.56	4.75	5.72	4.20	3.18	2.27	2.92	3.21	3.54	3.26	42.81
HOUSTON	93	45	109	5	3.78	3.44	2.67	3.24	4.32	3.69	4.29	4.27	4.26	3.77	3.86	4.36	45.95
KERRVILLE	94	34	110	- 7	1.86	2.07	2.02	3.07	4.19	2.99	2.32	1.85	4.22	3.14	1.52	2.25	31.50
KINGSVILLE	96	[illegible]	108	11	1.65	1.50	1.30	2.05	3.00	2.30	2.00	2.50	4.75	2.45	1.38	1.62	26.50
LUBBOCK	92	25	107	-16	.68	.57	.73	1.15	3.18	2.53	2.01	1.68	2.36	2.00	.54	.65	18.08
MARSHALL	95	37	112	- 9	4.75	4.01	4.40	4.43	5.25	3.18	3.28	2.53	2.70	3.01	4.41	5.01	46.96
McALLEN	96	48	106	17	1.18	1.03	.66	1.56	2.19	2.36	.88	1.84	3.69	2.58	.98	.84	19.79
McKINNEY	96	34	118	- 7	2.21	2.59	2.78	3.97	5.28	3.22	2.42	1.78	2.82	2.95	2.61	2.17	34.80
MEMPHIS	98	26	117	-11	.76	.77	.89	1.76	4.28	2.78	1.84	1.62	2.07	2.01	.50	.63	19.91
MIDLAND	95	31	109	-11	.80	.60	.36	.83	2.08	1.63	1.88	[illegible]	1.79	1.66	.47	.66	14.24
MULESHOE	92	20	110	-21	.65	.48	.62	1.02	2.80	2.48	2.37	2.21	1.99	1.62	.55	.65	17.44
PAMPA	94	23	109	-12	.53	.69	.79	1.50	3.62	3.00	2.48	2.19	1.91	1.83	.61	.81	20.16
PARIS	94	34	115	-13	3.08	3.45	3.47	5.19	5.40	4.26	3.65	2.73	3.52	3.22	3.78	3.36	45.11
PLAINVIEW	93	26	108	- 8	.80	.62	.68	1.53	3.18	2.58	2.47	2.05	2.02	1.64	.59	.82	18.96
PORT ARTHUR	91	44	107	11	4.23	4.45	3.44	3.94	4.94	4.29	6.00	5.49	4.88	2.88	3.46	5.09	53.09
SAN ANTONIO	94	42	107	0	1.74	1.65	1.67	2.82	3.45	2.95	2.09	2.36	3.49	2.50	1.37	1.75	27.84
TYLER	94	37	106	- 6	3.98	3.67	3.91	4.89	5.45	3.27	3.26	2.91	2.74	3.23	4.21	4.77	46.19
VICTORIA	92	46	110	9	2.34	2.34	2.32	2.62	4.12	3.04	3.61	3.13	4.23	3.45	2.36	2.61	36.20
WACO	96	38	[illegible]	- 5	2.27	2.42	2.35	3.88	4.57	2.67	1.99	1.66	2.77	2.55	2.19	2.74	32.08
WEATHERFORD	96	34	113	-11	2.14	2.46	2.16	3.58	5.39	3.00	[illegible]	1.67	2.70	3.04	1.82	2.12	31.37
WICHITA FALLS	97	31	113	-12	1.12	1.38	1.54	2.53	4.60	3.20	[illegible]	1.79	2.33	3.87	1.42	1.45	26.20

A - Average July Temperature
B - Average January Temperature
C - Record Highest
D - Record Lowest

CLIMATOLOGY OF FIVE TEXAS CITIES

AMARILLO, TEXAS / *elevation 3590 feet*

	Temperature				Degree Days	Rel. Hum. (%)	Precipitation		Wind		% Poss Sun	Average Number of Days of							Sun-rise 15th	Sun-set 15th	% IFR
	Average		Extreme				Total	Snow	mph	Dir		Rain .01"	Snow 1.0"	Thun	Fog	Sunup/Sundown					
	Max	Min	Max	Min												clr	pc	cld			
Jan	49	23	81	−11	921	52	1	4	13	sw	67	4	1	*	2	12	7	12	7:55	5:48	6
Feb	54	28	82	−14	753	50	1	3	14	sw	68	4	1	*	4	10	7	11	7:33	6:20	12
Mar	61	31	90	−3	605	43	1	3	15	sw	70	4	*	1	4	12	9	10	6:56	6:44	9
April	70	41	94	14	226	42	1	1	15	sw	71	6	*	4	3	11	9	10	6:16	7:10	7
May	78	50	102	28	90	47	3	T	14	s	70	9	0	9	2	10	11	10	5:48	7:44	9
June	88	60	108	42	0	43	3	0	14	s	78	8	0	9	1	13	12	5	5:43	8:08	3
July	92	64	104	53	0	44	3	0	12	s	77	9	0	11	1	13	13	5	5:43	8:08	4
Aug	90	63	105	59	0	43	3	0	12	s	76	8	0	9	*	15	11	5	6:08	7:38	1
Sept	83	56	102	32	37	44	2	T	11	s	77	5	0	4	1	17	7	6	6:33	6:54	5
Oct	72	45	95	25	210	47	2	T	13	sw	73	5	0	2	2	16	7	8	6:54	6:13	8
Nov	60	31	85	2	504	45	1	1	13	sw	70	3	*	*	3	17	7	6	7:20	5:41	6
Dec	51	24	81	3	820	49	1	2	13	sw	69	3	1	*	3	14	7	10	7:45	5:35	6
Year	71	43	108	−14	4345	46	21	13	14	s	73	69	3	50	22	160	107	98	.....	.....	6

elevation 16 feet / **BROWNSVILLE, TEXAS**

	Temperature				Degree Days	Rel. Hum. (%)	Precipitation		Wind		% Poss Sun	Average Number of Days of							Sun-rise 15th	Sun-set 15th	% IFR
	Average		Extreme				Total	Snow	mph	Dir		Rain .01"	Snow 1.0"	Thun	Fog	Sunup/Sundown					
	Max	Min	Max	Min												clr	pc	cld			
Jan	70	51	87	23	310	85	1	T	13	sse	47	7	0	1	6	7	8	16	7:18	6:00	14
Feb	73	54	94	20	189	83	1	T	13	sse	49	7	0	1	5	7	6	15	7:06	6:23	16
Mar	77	58	90	30	74	82	1	T	14	se	49	5	0	1	3	6	9	16	6:39	6:38	14
April	82	65	100	45	0	80	2	0	14	se	53	4	0	2	3	5	11	14	6:07	6:53	9
May	87	71	100	55	0	80	3	0	14	se	60	4	0	3	1	7	15	9	5:44	7:08	5
June	91	74	101	60	0	80	3	0	13	se	73	5	0	2	*	7	17	6	5:38	7:20	4
July	93	75	100	68	0	83	2	0	12	se	81	4	0	3	0	12	14	5	5:47	7:24	1
Aug	93	75	100	66	0	80	3	0	11	se	77	7	0	4	0	10	15	6	6:02	7:08	1
Sept	90	73	104	55	0	85	5	0	10	se	68	10	0	4	*	9	14	7	6:15	6:34	2
Oct	86	66	93	40	0	81	3	0	10	se	66	7	0	2	1	13	12	7	6:28	6:08	5
Nov	77	58	94	34	30	84	2	0	11	sse	50	7	0	1	3	8	9	13	6:48	5:41	6
Dec	70	52	90	20	150	84	2	0	11	wsw	47	6	0	*	5	7	8	16	7:08	5:41	14
Year	83	65	104	20	617	81	28	T	12	se	61	70	0	23	24	97	138	130	.....	.....	8

DALLAS, TEXAS / *elevation 476 feet*

	Temperature				Degree Days	Rel. Hum. (%)	Precipitation		Wind		% Poss Sun	Average Number of Days of							Sun-rise 15th	Sun-set 15th	% IFR
	Average		Extreme				Total	Snow	mph	Dir		Rain .01"	Snow 1.0"	Thun	Fog	Sunup/Sundown					
	Max	Min	Max	Min												clr	pc	cld			
Jan	55	36	88	2	667	60	2	1	10	s	47	7	1	1	1	8	6	17	7:30	5:44	17
Feb	60	40	88	7	445	61	3	T	11	s	50	8	*	3	1	8	6	14	7:11	6:13	11
Mar	68	47	90	11	300	54	3	T	13	s	56	8	*	4	1	10	8	13	6:38	6:35	7
April	77	56	96	31	75	56	4	0	12	sse	56	9	0	6	*	9	8	13	5:56	6:57	10
May	84	64	96	30	0	58	4	0	12	s	60	9	0	7	*	9	10	12	5:30	7:18	3
June	93	73	103	53	0	55	3	0	12	s	75	5	0	5	*	13	11	6	5:19	7:37	1
July	95	76	111	61	0	50	2	0	10	s	78	5	0	4	*	15	9	7	5:30	7:37	2
Aug	96	76	109	61	0	48	2	0	10	sse	77	5	0	4	*	16	10	5	5:50	7:13	1
Sept	89	69	106	36	0	49	3	0	9	se	74	5	0	3	*	16	8	6	6:11	6:34	4
Oct	80	58	99	30	83	51	3	0	9	se	70	6	0	3	1	15	7	9	6:31	5:55	5
Nov	66	45	89	17	380	51	3	T	10	s	63	6	0	2	1	14	6	10	6:57	5:26	10
Dec	58	39	89	13	618	58	3	T	10	sse	54	6	*	1	2	11	6	14	7:20	5:25	10
Year	77	56	111	2	2272	54	35	2	11	s	66	81	1	45	7	143	94	128			7

elevation 3920 feet / **EL PASO, TEXAS**

	Temperature				Degree Days	Rel. Hum. (%)	Precipitation		Wind		% Poss Sun	Average Number of Days of							Sun-rise 15th	Sun-set 15th	% IFR
	Average		Extreme				Total	Snow	mph	Dir		Rain .01"	Snow 1.0"	Thun	Fog	Sunup/Sundown					
	Max	Min	Max	Min												clr	pc	cld			
Jan	58	31	73	−5	670	44	T	2	10	n	75	3	1	*	1	13	9	10	8:05	6:34	3
Feb	62	35	81	8	456	36	T	1	11	n	78	3	*	*	*	14	7	7	7:48	7:02	1
Mar	68	41	88	16	330	30	T	1	13	wsw	81	2	*	[illegible]	*	14	8	9	7:16	7:14	1
April	77	49	95	28	110	28	T	T	13	wsw	85	2	0	[illegible]	*	18	8	6	6:37	7:34	2
May	85	56	104	38	0	23	T	0	12	w	88	2	0	[illegible]	0	18	9	4	6:09	7:56	1
June	94	67	109	50	0	25	1	0	11	w	88	4	0	[illegible]	0	19	8	3	5:50	8:13	1
July	94	69	109	60	0	36	1	0	10	s	77	8	0	[illegible]	0	12	13	6	6:10	8:13	1
Aug	92	68	103	59	0	39	1	0	10	s	80	7	0	[illegible]	0	14	13	4	6:30	7:49	1
Sept	87	61	102	41	0	37	1	0	9	s	82	4	0	3	*	19	6	5	6:49	7:13	1
Oct	78	50	93	32	70	37	1	0	9	n	82	4	0	2	*	18	8	5	7:09	6:34	2
Nov	66	38	84	16	300	36	T	T	10	n	84	2	*	*	*	19	6	5	7:34	6:06	1
Dec	57	33	76	5	626	42	T	1	10	n	77	3	*	*	*	17	5	8	7:58	6:05	1
Year	78	50	109	−5	2641	34	8	4	11	n	80	44	1	35	1	194	90	78	.....	.....	1

HOUSTON, TEXAS / *elevation 41 feet*

	Temperature				Degree Days	Rel. Hum. (%)	Precipitation		Wind		% Poss Sun	Average Number of Days of							Sun-rise 15th	Sun-set 15th	% IFR
	Average		Extreme				Total	Snow	mph	Dir		Rain .01"	Snow 1.0"	Thun	Fog	Sunup/Sundown					
	Max	Min	Max	Min												clr	pc	cld			
Jan	63	45	83	10	378	66	4	T	11	n	46	10	*	2	3	8	7	16	7:16	5:44	23
Feb	66	50	96	5	267	65	3	T	11	se	44	10	*	2	3	6	7	15	7:01	6:10	25
Mar	71	54	96	21	106	80	3	0	12	se	51	9	0	3	3	8	8	15	6:32	6:30	12
April	78	61	92	30	27	60	3	0	12	se	54	8	0	5	1	7	8	15	5:55	6:48	11
May	85	67	96	45	0	80	5	0	11	se	60	8	0	6	1	6	12	13	5:29	7:07	9
June	90	74	99	57	0	80	4	0	10	s	70	8	0	7	*	7	15	8	5:20	7:23	1
July	92	75	106	64	0	58	4	0	8	s	60	10	0	11	0	6	16	9	5:31	7:24	1
Aug	93	75	100	63	0	80	3	0	8	s	66	9	0	9	*	7	15	9	5:49	7:03	4
Sept	89	71	99	45	0	80	4	0	9	se	64	9	0	5	*	9	11	10	6:06	6:27	5
Oct	82	63	97	37	0	86	3	0	9	se	67	7	0	3	3	12	10	9	6:21	5:51	10
Nov	71	55	89	26	162	58	4	0	10	se	57	8	0	2	3	10	8	12	6:40	5:26	13
Dec	64	47	83	20	303	84	5	T	10	se	48	10	0	2	3	9	6	16	7:09	5:24	18
Year	79	61	106	10	1276	60	45	T	10	se	56	108	*	58	16	96	133	147			11

FIGURE 2.6

GLOBE THERMOMETER FOR DETERMINING MEAN RADIANT TEMPERATURE

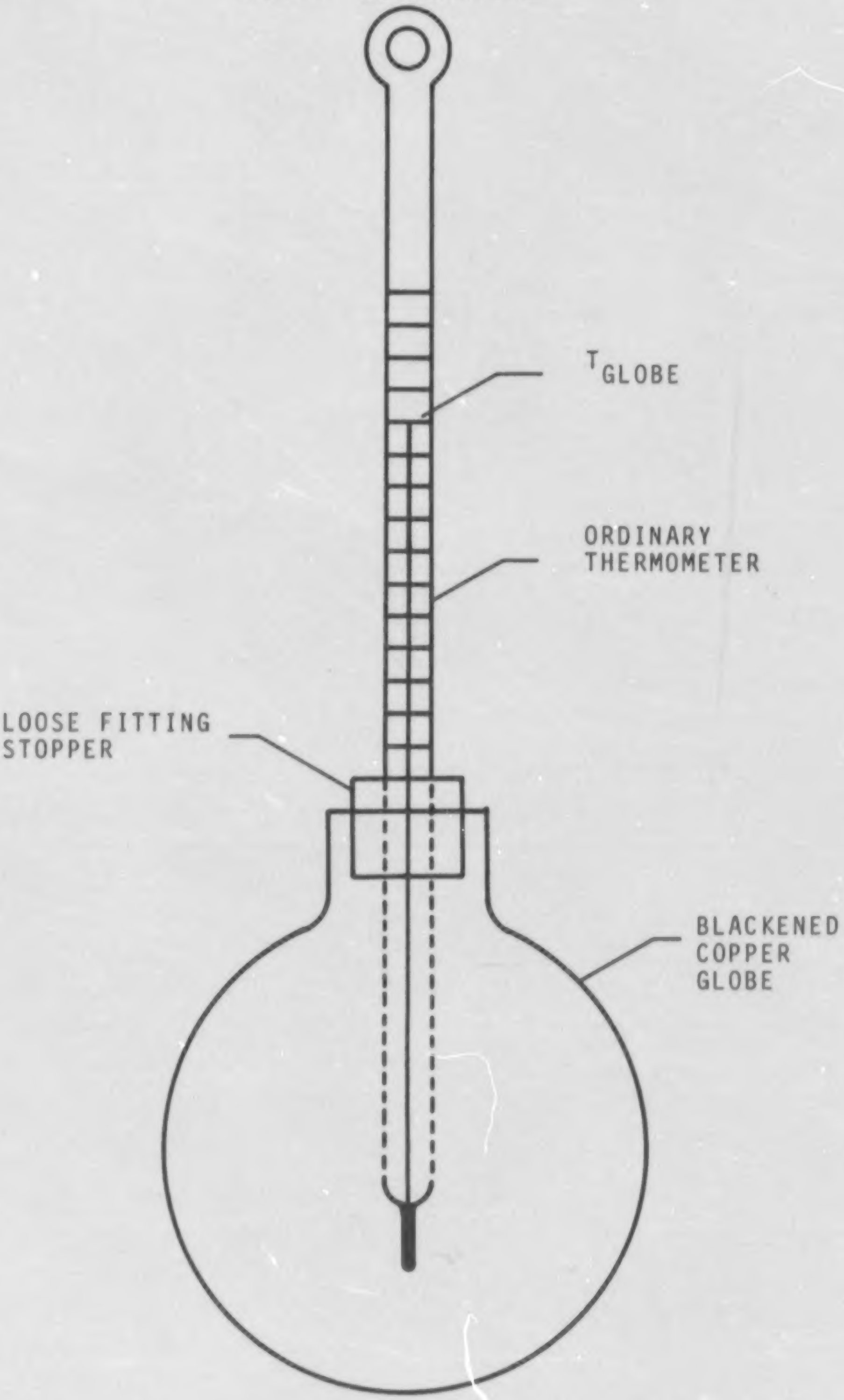

T_{GLOBE}
ORDINARY THERMOMETER
LOOSE FITTING STOPPER
BLACKENED COPPER GLOBE

FIGURE 2.7

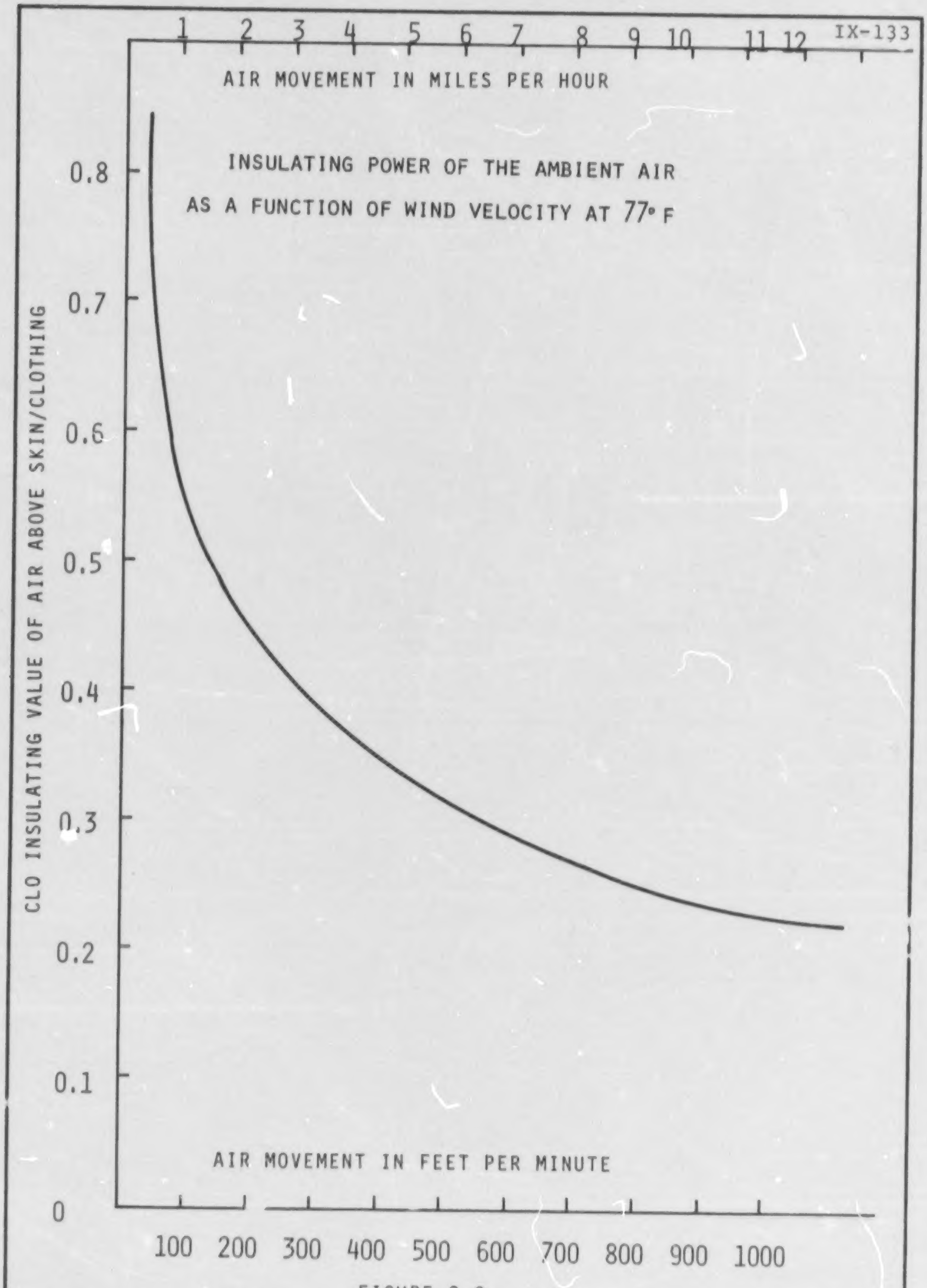

1
2
3
4
5
6
7
8
9
10
11
12
AIR MOVEMENT IN MILES PER HOUR
INSULATING POWER OF THE AMBIENT AIR
AS A FUNCTION OF WIND VELOCITY AT 77° F
CLO INSULATING VALUE OF AIR ABOVE SKIN/CLOTHING
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
AIR MOVEMENT IN FEET PER MINUTE
100
200
300
400
500
600
700
800
900
1000

FIGURE 2.8

TEMPERATURE$_{\text{DRY BULB}}$/TEMPERATURE$_{\text{WET BULB}}$ CHART

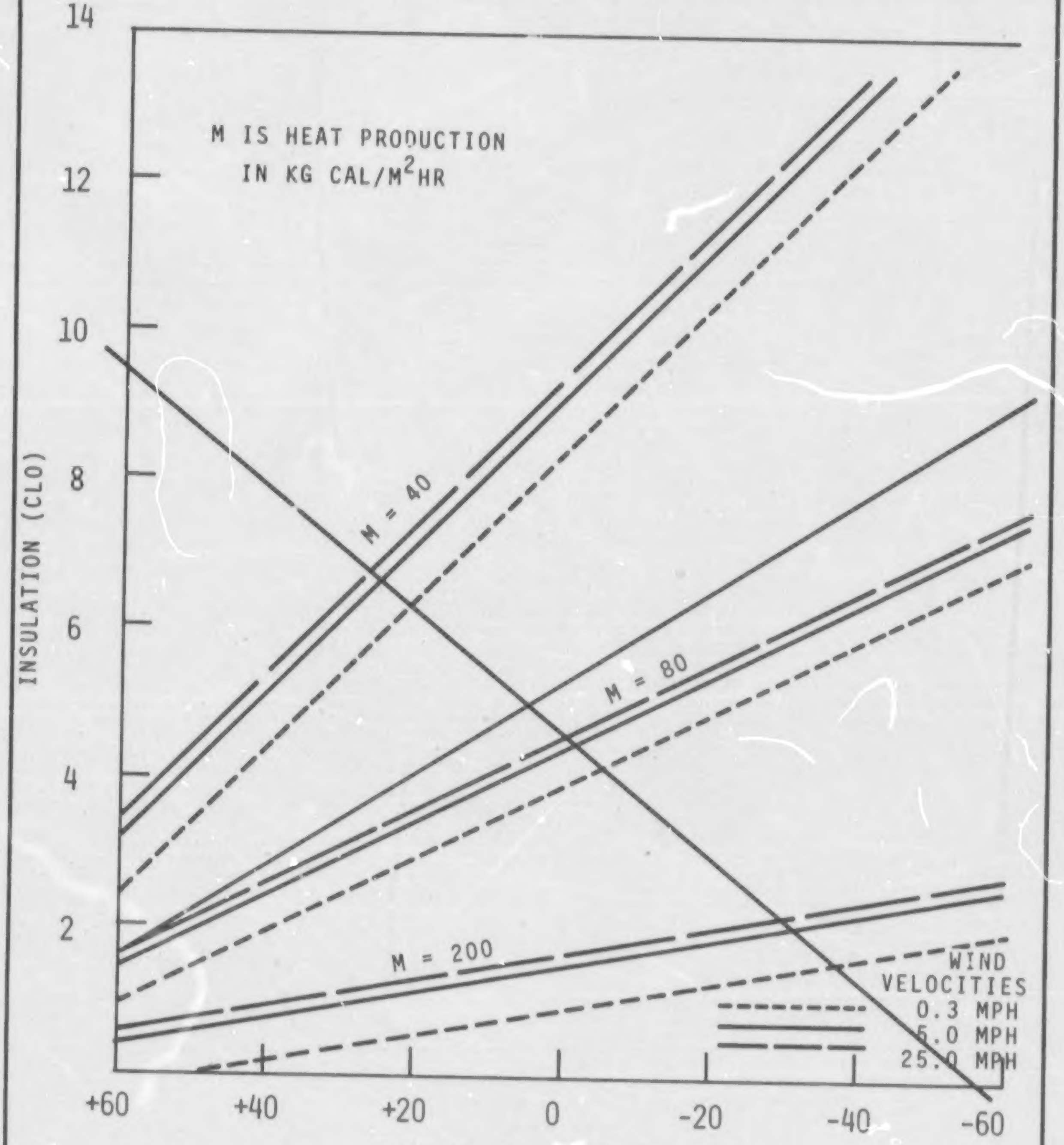


FIGURE 2.9

OUTDOOR TDB/TWB CHART FOR REPRESENTATIVE TEXAS CITIES

	Higher Summer TDB			Lowest Winter TDB		Daily TDB Range	Highest TWB
	1	2	3	4	5	6	7
WICHITA FALLS	103/73°	101/73°	98/73°	14	18	24	75-77
DALLAS	102/75°	100/75°	97/75°	18	22	20	77-78
CORSICANA	100/75°	98/75°	96/75°	20	25	21	77-79
AUSTIN	100/74°	98/74°	97/74°	24	28	22	77-78
EL PASO	100/64°	98/64°	96/64°	20	24	27	68-69
SAN ANTONIO	99/72°	97/73°	96/73°	25	30	19	76-77
AMARILLO	98/67°	95/67°	93/67°	6	11	26	70-71
HOUSTON	97/77°	95/77°	93/77°	28	33	18	79-80
CORPUS CHRISTI	95/78°	94/78°	92/78°	31	35	19	79-80

All values in °F TDB/TWB except where indicated

1. Column 1, 2 and 3 give TDB/TWB for 1%, 2-1/2% and 5% of summer days. Only 1 day in 100 is column 1 exceeded; only on 2-1/2 days is Column 2 exceeded and so on.

2. Columns 4 and 5 give TDB for 99% and 97-1/2% of winter days. In 99% (97-1/2%) of winter days, these values are exceeded.

3. Column 6 shows the mean daily range in TDB. Thus, El Paso commonly experiences a TDB fluctuation of 27°F between the hottest hour during the day and the coldest hour during the night.

4. Column 7 shows TWB for the 15 days when the atmosphere was most humid in a recent 5 year period. Thus, Corpus Christi and Houston experience greater humidity than Amarillo and El Paso.

FIGURE 2.10

OCCUPANCY AND DURATION OF STAY IN BUILDING TYPES

	SPACE OR BUILDING	OCCUPANCY	DURATION OF STAY PER PERSON
1.	ENTRANCE LOBBIES	FEW AT A TIME	SHORT
2.	ELEVATORS	ONE OR SEVERAL	SHORT
3.	CONVENIENCE STORES	SEVERAL	MINUTES
4.	RESTAURANTS	VARIABLE	1/2 - 1 HOUR
5.	CLASSROOM	SUBSTANTIAL	3/4 - 1 1/2 HOURS
6.	LIBRARIES	SEVERAL OR MANY	VARIABLE
7.	CHURCHES	SUBSTANTIAL	1-2 HOURS
8.	SPORTS ARENAS	THOUSANDS	2-3 HOURS
9.	MOVIE THEATERS	HUNDREDS	2-4 HOURS
10.	OFFICES	FEW	8 HOURS
11.	MOTEL ROOM	ONE OR TWO	8 HOURS OR MORE
12.	HOSPITAL ROOM	ONE OR TWO	24 HOURS OR MORE

FIGURE 3.1

"COMFORTABLE" LINES FOR MEN EXPOSURE PERIODS OF 1.0, 2.0, AND 3.0 HOURS

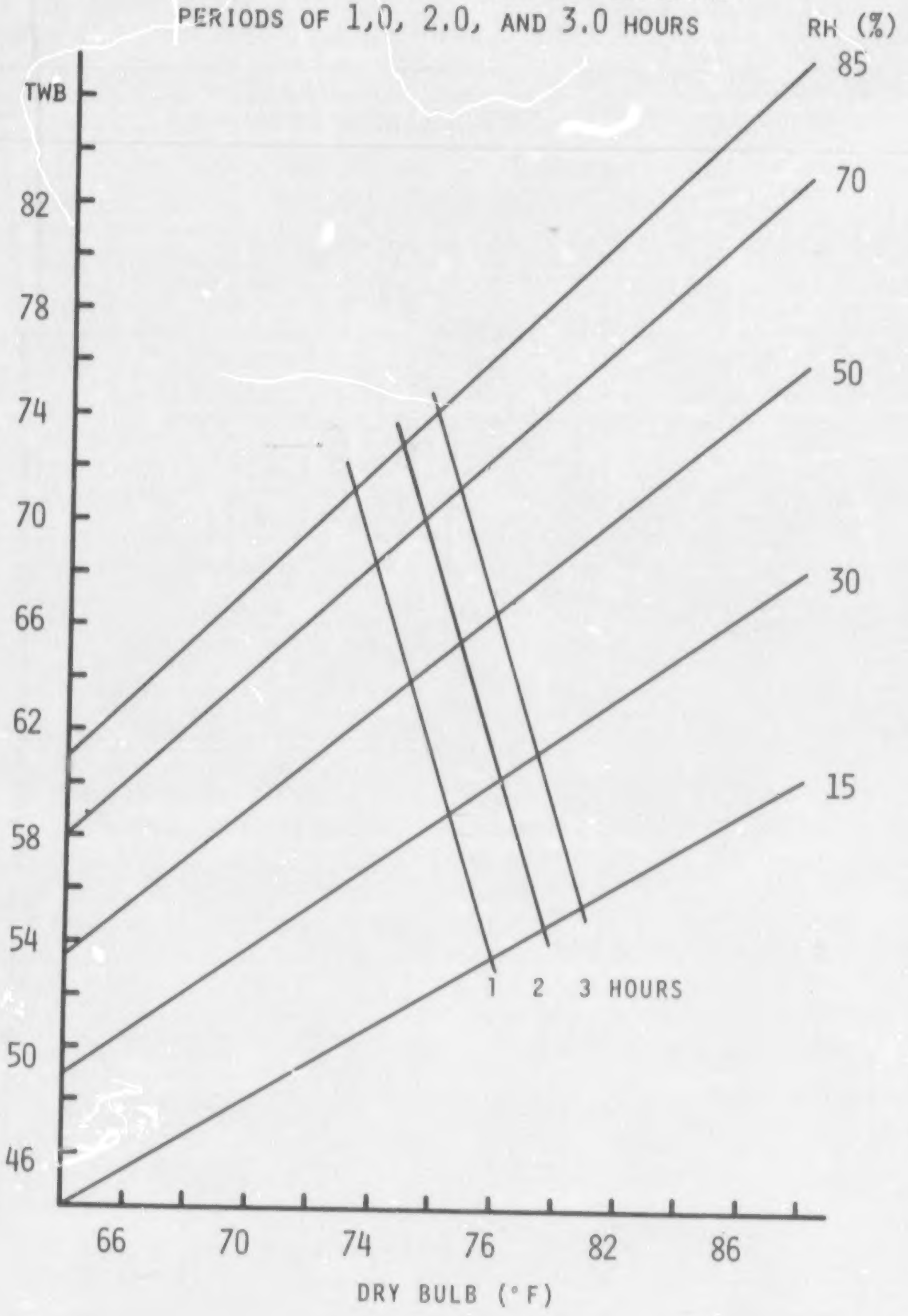


FIGURE 3.2a

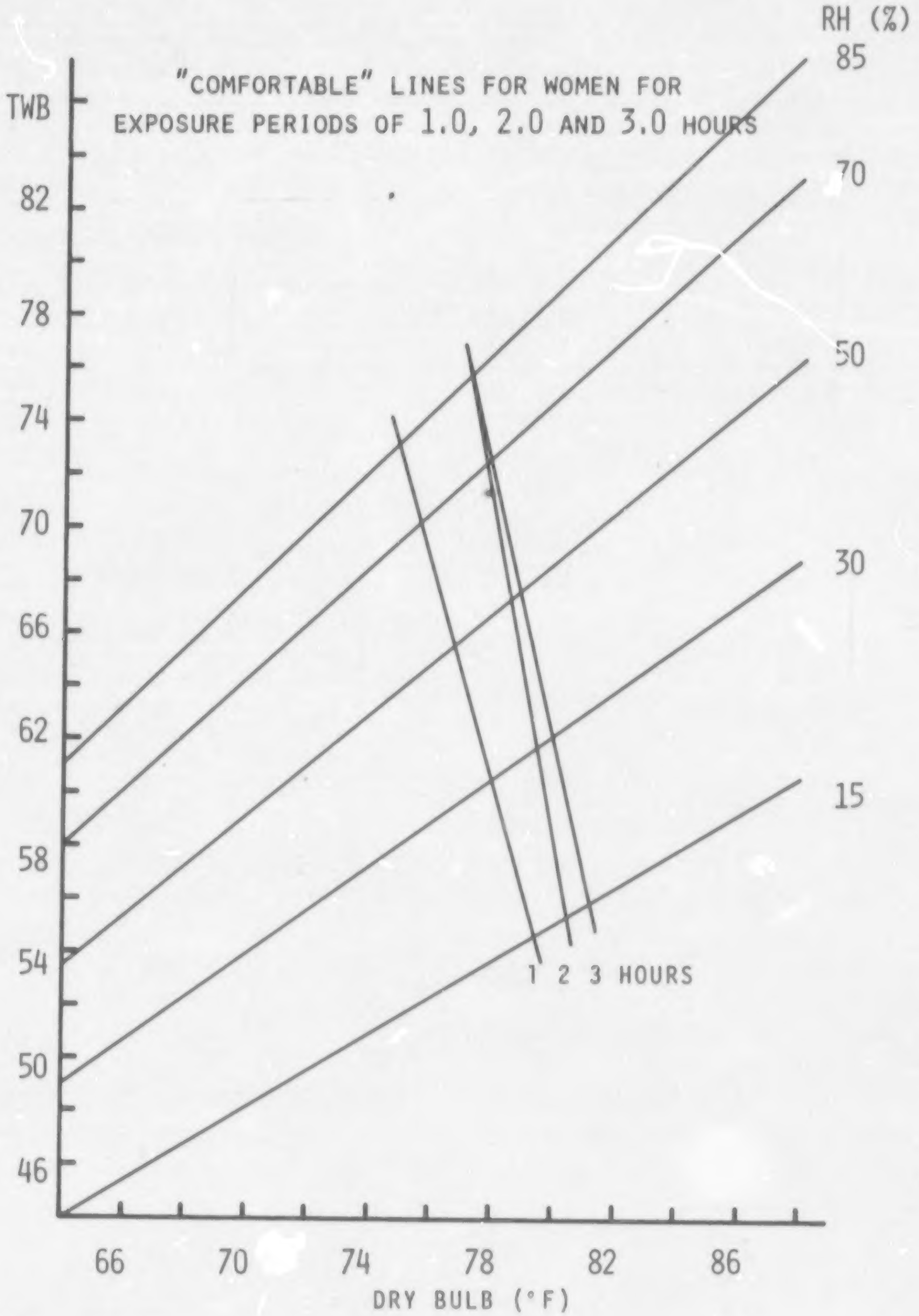

"COMFORTABLE" LINES FOR WOMEN FOR EXPOSURE PERIODS OF 1.0, 2.0 AND 3.0 HOURS
TWB
82
78
74
70
66
62
58
54
50
46
RH (%)
85
70
50
30
15
1 2 3 HOURS
66
70
74
78
82
86
DRY BULB (°F)

FIGURE 3.2b

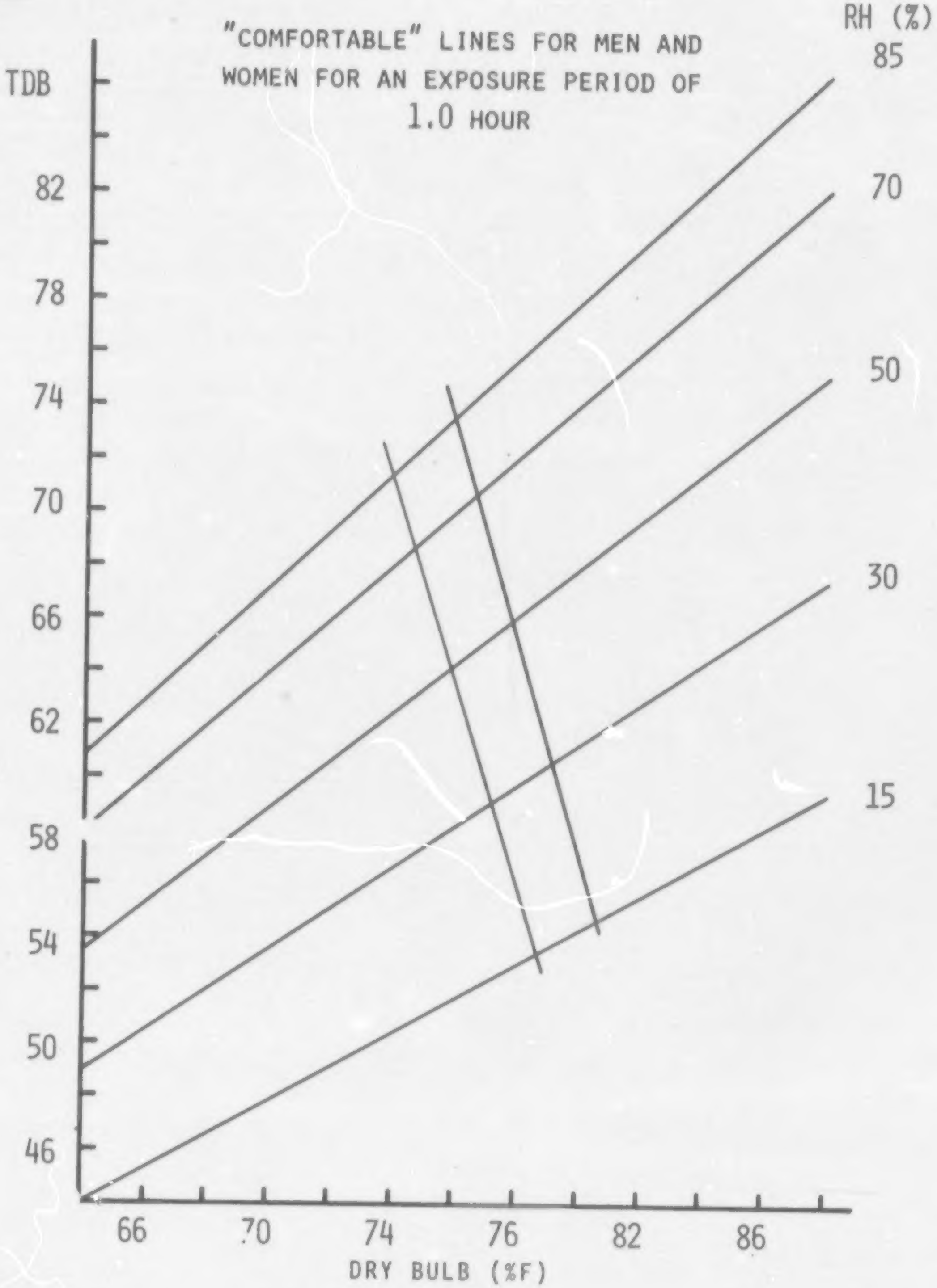

"COMFORTABLE" LINES FOR MEN AND WOMEN FOR AN EXPOSURE PERIOD OF 1.0 HOUR
RH (%)
85
70
50
30
15
TDB
82
78
74
70
66
62
58
54
50
46
66
70
74
76
82
86
DRY BULB (%F)

FIGURE 3.2c

TABLE OF HEAT PRODUCTION RATES

	TYPICAL VALUES FOR BTU/HR
ASLEEP	
SLEEPING, MEN OVER 40	260
SLEEPING, MEN AGED 30-40	280
SLEEPING, MEN AGED 20-30	280
RESTING	
LYING MODERATELY RELAXED	320
LYING AWAKE--AFTER MEALS	340
SITTING AT REST	400
VERY LIGHT ACTIVITY--SEATED	
WRITING	430
TYPING	550
POLISHING	570
VERY LIGHT ACTIVITY--STANDING	
RELAXED	440
TYPING	460
POLISHING	480
LIGHT ACTIVITY--SEATED	
PLAYING MUSICAL INSTRUMENTS	690
REPAIRING BOOTS AND SHOES	720
AT LECTURE	730
LIGHT ACTIVITY--STANDING	
WASHING CLOTHES	610
IRONING	890
SCRUBBING	1040
LIGHT ACTIVITY--MOVING	
SLOW MOVEMENT ABOUT ROOM	600
VEHICLE REPAIR	820
WASHING	1000
MODERATE ACTIVITY--SITTING	
ROWING FOR PLEASURE	1190
CYCLING AT 8-11 MPH	1360
CYCLING RAPIDLY	1640

FIGURE 3.3

	Typical values for BTU/hr
Moderate activity--standing	
Gardening	1380
Chopping wood slowly	1480
Shoveling sand slowly	1620
Moderate activity--moving	
Golf	1290
Table tennis	1380
Tennis	1500
Heavy activity--lying	
Leg exercises, average	1790
Swimming breast stroke at 1.6 mph	1950
Swimming backstroke at 1.0 mph	1980
Heavy activity--sitting	
Cycling rapidly--own pace	1980
Cycling at 10 mph--heavy bicycle	2120
Cycling in race 100 mi in 4 hr., 22 min.	2340
Heavy activity--standing	
Chopping wood rapidly	1790
Shoveling sand rapidly	1830
Sawing wood by hand	1900
Heavy activity--moving	
Skating at 9 mph	1860
Skiing at 8 mph on level	2140
Climbing stairs at 116 steps per minute	2340
Very heavy activity--sitting	
Cycling at 13.2 mph	2380
Galloping on horseback	2720
Sculling 97 strokes/min.	3000

FIGURE 3.3 (CONT.)

	TYPICAL VALUES FOR BTU/HR
VERY HEAVY ACTIVITY--MOVING	
FENCING	2500
PLAYING BASKETBALL	2720
CLIMBING STAIRS	2860
EXTREME ACTIVITY	
WRESTLING	3100
MARCHING AT DOUBLE	3160
ENDURANCE MARCHING	3520

NOTE:

BTU/HR IS THE RATE OF HEAT PRODUCTION PER HOUR. THESE MEASUREMENTS ARE GIVEN FOR A PERSON 69 INCHES TALL AND 167 POUNDS IN ABSOLUTE UNITS.

SOURCE: JOHN FLETCHER, ENVIRONMENT, ENERGY AND SOCIETY, 1973.

FIGURE 3.3 (CONT.)

HEAT LOSS

TYPICAL ACTIVITY	EVAPORATIVE HEAT LOSS	CLO FOR HEAT BALANCE
SLEEPING	53 BTU/HR.	0.6 LIGHT WINTER CLOTHING
SCRUBBING	226 BTU/HR.	0.14 T-SHIRT & BRIEFS, BRA & SHORTS
CLIMBING STAIRS	644 BTU/HR.	0.05 BRIEFS ONLY

FIGURE 3.4

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. Heating, Ventilating, and Air Conditioning Conservation Opportunities may be offered independently or as part of a sequence of 3 modules in the following order:

Order	Module	Title of Module
1	9	Human Comfort and Energy Conservation
2	8	Building Construction vs Energy Consumption
3	10	Heating, Ventilating, and Air Conditioning Conservation Opportunities

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

MODULE DESCRIPTION:

This module discusses the principles of air conditioning (heating and cooling) in buildings, including heat loss, heat gain, heating loads, and cooling loads. Heating and cooling load characteristics for sizing home heating and cooling equipment requirements are discussed in terms of relative humidity, and summer and winter design temperatures.

Heating and cooling equipment are described in terms of components of operation, energy efficiency ratings, and equipment energy usage and design. Ductwork is explored as the delivery system of home conditioned air. Cost/benefit analysis of energy conservation opportunities in heating, ventilating, and air conditioning are explored in the areas of equipment operation, maintenance, and control.

GOAL STATEMENT:

The objective of this module is to train secondary and postsecondary students in the recognition, implementation, and utilization of energy consumption, and possible conservation in heating, ventilating, and air conditioning.

READING GRADE LEVELS:

Lecture: 11
Lab : 9

SUGGESTED TEACHING TIMES:

Secondary : 3-5 hours
Postsecondary: 1 1/2-3 hours

MODULE X

UNIT I. Fundamentals of Heating and Cooling Introduction

- A. Energy Units
- B. Temperature Differences
- C. Humidity

UNIT II. Heating Systems

Introduction

- A. Forced Air Components
- B. Sizing a Heating System
- C. Fuel Costs
- D. Heating System Efficiency
  - 1. Fuel Furnaces
  - 2. Electric Furnaces
  - 3. Heat Pumps
  - 4. Electric Baseboard Heaters
- E. Maintenance
  - 1. Filters
  - 2. Fans
  - 3. Adjusting LPG and Natural Gas Furnaces
    - a. Gas Valves
    - b. Adjusting the Air Mixture
    - c. Cleaning the Burners
    - d. Adjusting the Gas Pressure
    - e. Adjusting the Pilot Light

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

TERMINOLOGY

Absorption--the process whereby heat extracts one or more substances present in an atmosphere or mixture of gases or liquids, accompanied by physical or chemical change, or both changes of the material.

Absorption chiller--a refrigeration unit based upon absorption refrigeration.

Absorption refrigeration--cooling which is effected by the expansion of liquid ammonia into gas by water. Heat is the primary source of energy.

Active--when applied to building design, refers to the mechanical movement of energy by the use of an external force of energy.

Air change--the movement of a volume of air in a given period; if a house has one air change per hour, all of the air in the house will be replaced in a one-hour period. Air changes are expressed in cubic feet per minute.

Air conditioning--the process of treating air to control temperature, humidity, flow, and odor.

Ambient temperature--temperature of the outside air.

Attic ventilation--may be screened openings provided to ventilate an attic space located in the soffit area as inlet ventilators, and in the gable ends or along the ridge as outlet ventilators; can also consist of power-driven fans used as an exhaust system.

Berm--a mound or small hill of earth, man-made.

British thermal unit (Btu)--the amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit; a unit of heat roughly equal to the amount of heat given off by burning a kitchen match.

Building skin--the physical structure which encloses a building.

Bypass loop--a piping arrangement which bypasses or circles the flow of a heat absorbing medium around, rather than through, a piece of mechanical equipment.

CFM - an abbreviation for cubic feet per minute.

Capacity - the usuable output of a system.

Centrified fan - a machine for moving a gas, such as air, by accelerating it rapidly outward in an impeller to a surrounding casing; generally of a scroll shape.

Change of state (phase change) - the change from solid, or gas to either of the other two.

Chimney effect - the tendency of air or gas in a duct or other vertical passage to rise when heated due to its lower density compared with that of the surrounding air or gas. In buildings, the tendency toward displacement (caused by the difference in temperature) of internal heated air by unheated outside air due to the difference in density of outside and inside air.

Coil - a cooling or heating element made of pipe or tubing.

Comfort zone - the ranges of indoor temperature, humidity, and air movement under which most persons enjoy mental and physical well-being.

Compression - in a compression refrigeration system, a process by which the pressure and temperature of the refrigerant is increased to allow for greater heat transfer.

Conduction - a process of heat transfer whereby heat moves through a material.

Convection - transfer of heat by movement of a fluid or gas.

Crack method - a method used in the calculation of air movement from the outside into an enclosed space. The method is based on the rate through one foot of crack between sash and frame or between door and frame.

DHW tank - abbreviated form for Domestic Hot Water tank.

Damper - a device used to vary the volume of air passing through an air outlet, inlet or duct.

Dehumidification - the condensation of water vapor from air by cooling below the dew point or removal of water vapor from air by chemical or physical methods.

Density - the weight per unit volume.

Diurnal cycle - the day-to-night change or cycle of natural phenomenon. An example is the variation of outdoor temperature throughout a twenty-four hour period.

Dry bulb temperature - a measure of the sensible temperature of air (the one with which we are most familiar).

Economizer cycle - a cooling mode which uses cool outdoor air to offset heat gains in buildings rather than using an energy consuming cooling device.

Electronic air filter - the use of electricity to set up a static charge which can remove dust and other particulate matter.

Energy - the capacity for doing work; taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical and chemical; in customary units, measured in kilowatt hours (KWH) or British Thermal Units (BTU); in SI units, measured in joules (J), where 1 joule = 1 watt-second.

Enthalph - a measurement of the total energy content of the air. The total energy content is composed of both sensible and latent heat as measured by the dry bulb and wet bulb temperatures.

Evaporative cooling - lowering the temperature of a large mass of liquid by utilizing the latent heat of vaporization of a portion of the liquid; cooling air by evaporating water into it.

Flow rate - velocity at which a fluid travels, usually through an opening or duct.

Frequency of occurrence - the number of times a given event will occur during a given period of time.

GPM - an abbreviation for gallons per minute.

Greenhouse effect - the effect of the earth's atmosphere in trapping heat from the sun. The atmosphere acts like a greenhouse by admitting the sun's shortwave radiation but blocking the exit of long wavelength radiation re-emitted by the earth or other warned objects.

Heat capacity - sometimes called the thermal capacity, a measure of how much heat is required to raise the temperature of a specific quantity of material by a given amount.

Heat dissipator - the method of transmitting energy or power out of a system in the form of heat.

Heat exchanger - a device used to transfer heat from one medium to the other.

Heat gain - an increase in the amount of heat contained in a space, resulting from direct solar radiation and the heat given off by people, lights, equipment, machinery, and other sources.

Heat loss - a decrease in the amount of heat contained in a space, resulting from heat flow through walls, windows, roof, and other building envelope components.

Heat pump - a reversible refrigeration system that delivers more heat energy to the end use than is put in to the compressor. The additional energy input results from the absorption of heat from a low temperature source--the combination heating and cooling unit. It operates like a normal air conditioner in summer, and in winter operates in reverse, ejecting warm air indoors and cool air (or water) outdoors.

Heat wheel - a device used in ventilating systems which tends to bring incoming air into thermal equilibrium with existing air. As a result, hot summer air is cooled and cold winter air is warmed.

Humidifier - a device to add moisture to air.

In-line pump - a pump which is supported by the piping system.

Incident - usually used in the term "incident radiation" which is the amount of energy striking a collector surface before entering the collector.

Infiltration - the uncontrolled flow of air into and out of a building through cracks, openings, doors, or other areas which allow air to penetrate.

Initial cost - the original price of an item or system.

Insulation, thermal - any material high in resistance to heat transmission that, when placed in the walls, ceilings, or floors of a structure, will reduce the rate of heat flow.

Kilowatt Hour (KWH) - unit of electrical energy consumption which equals about 3,400 BTU.

Latent heat - a change in heat content that occurs without a corresponding change in temperaure, usually accompanied by a change of state.

Peak load - maximum predicted energy demand of a system.

Perms-permeance - the ratio of water vapor flow to the vapor pressure difference of the surfaces; permeance is expressed in perms or (grains)/(Sq.Ft.)(Hr,), and of mercury vapor pressure difference.

Psychrometric - pertaining to the device comprising two thermometers, one a dry bulb, the other a wet bulb or wick-covered bulb, used in determining the moisture content or relative humidity of air or other gases.

R-value resistance - the resistance of a material to the flow of heat or energy.

Reflectance - a property of a material indicating the percentage of light that is reflected when a certain amount of light strikes the surface of the material or is transmitted through it.

Relative humidity - the ratio of the amount of water vapor at a given temperature to the maximum amount of water vapor that could be held as vapor.

Sensible heat - heat that results in a temperature change.

Set back - the lowering of the thermostat setting. The technique is used to reduce the amount of heat required to heat a space.

Set up - the raising of the thermostat setting. The technique is used to reduce the amount of cooling required to cool a space.

Shortwave radiation - a term used loosely to distinguish radiation in the visible and near-visible portions of the electromagnetic spectrum (roughly 0.4 to 1.0 micrometers in wavelength) from longwave radiation (infra-red radiation).

Sling psychrometer - a psychrometer in which the wet and dry bulb thermometers are mounted upon a frame and connected to a handle at one end by means of a bearing or a length of chain. It may be whirled in the air for the simultaneous measurement of wet and dry bulb temperatures.

Solar intensity - the amount of solar radiation.

Solenoid value - a value actuated by a solenoid or an electronic impulse for controlling the flow of gases or liquids in pipes.

Space heating - interior heating of a building or room.

Stagnation - the condition of a fluid or gas unstirred by a current or flow.

Thermal comfort - the zone in which a majority of the human population would not feel too hot or too cold.

Thermal lag - the ability of materials to delay the transmission of heat; can be used interchangeably with time lag.

Thermal sensation - the ability of the body to sense the temperature as being too hot or too cold.

Time lag - the time between a cause and a resultant effect, as between occurrence of heat input on an exterior surface of a wall and the time until the heat is transmitted to the interior wall surface.

Ton (of air conditioning) - the thermal refrigeration energy required to melt one ton of ice (2,000 pounds); equals 12,000 BTU.

"U" value - a coefficient which indicates the energy (BTU) which passes through a component for every degree (Fahrenheit) of temperature difference from one side to the other under steady state conditions.

Vapor barrier - a component of construction which is impervious to the flow of moisture or air.

Vapor pressure - the force exerted when moist air attempts to seek equilibrium by migrating to areas with less water vapor.

Ventilation air - outside air that is intentionally allowed to enter an interior space.

Weatherstripping - foam, metal, or rubber strips used to form a seal around windows, doors, or openings to reduce infiltration.

Wet bath temperature - the lowest temperature attainable by evaporating water into the air, without altering the energy content.

MODULE #10

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

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MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. Coal, gas, and oil are _______ energy sources.

   a. renewable
   b. non-renewable

2. _______ percent of the total U.S. energy budget is devoted to heating and cooling:

   a. 5.2
   b. 10.4
   c. 15.7
   d. 25.6

3. A Btu is the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit.

   a. true b. false

4. The energy efficiency ratio (EER) is a way to compare the efficiencies of various air conditioners.

   a. true b. false

5. The summer design temperature tells how hot it is expected to get in the summer.

   a. true b. false

6. The heating and cooling loads for a home will, obviously, always be the same.

   a. true b. false

7. _______ air speeds up evaporation:

   a. warm b. cool

8. The output capacity of heating equipment should not be less than the calculated heating load but it should not exceed the calculated heat load by more than _______ percent:

   a. 15
   b. 25
   c. 35
   d. 50

9. The efficiency of a heating system is based on the amount of heat energy that actually goes into the living area, which is compared to the total amount of heat generated inside the furnace.

   a. true   b. false

10. The advantage of electric heating over heating by natural gas is that:

    a. it is less expensive
    b. it does not require a flue
    c. both a and b

11. Electric baseboards have an efficiency approaching:

    a. 25%
    b. 50%
    c. 75%
    d. 100%

12. All forced-air furnaces have air filters.

    a. true   b. false

13. Dirty air filters do not affect the efficiency of a forced air furnace.

    a. true   b. false

14. In the operation of electric furnaces, most of the heat loss occurs:

    a. through the flue
    b. through the duct system

15. It never gets too cold for a heat pump to work.

    a. true   b. false

16. During the winter, a relative humidity of less than _______ percent makes the air feel dry and irritates the nose and throat.

    a. 30
    b. 40
    c. 50
    d. 60

17. As far as space heaters are concerned, _______ should be considered last because they are heavy users of energy:

    a. electric heaters
    b. coal heaters
    c. wood stoves
    d. natural gas stoves

18. One of the biggest reasons an air conditioner does not perform to expectations is that the unit is:

    a. too big
    b. too little

19. Cool air will circulate by itself as readily as warm air.

    a. true b. false

20. The condenser of an air conditioning system should not be sheltered from natural wind currents.

    a. true b. false

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

ANSWERS TO PRETEST

1. b. non-renewable
2. c. 15.7
3. a. true
4. a. true
5. a. true
6. b. false
7. a. warm
8. a. 15
9. a. true
10. b. it does not require a flue
11. d. 100%
12. a. true
13. b. false
14. a. through the flue
15. b. false
16. a. 30
17. a. electric heaters
18. b. too little
19. b. false
20. a. true

MODULE X

HEATING, VENTILATING, AND AIR CONDITION CONSERVATION OPPORTUNITIES

UNIT I

FUNDAMENTALS OF HEATING AND COOLING

UNIT OBJECTIVES

1. Discuss energy use in the U.S. in terms of types of fuel used for various activities.

2. Identify units of measurement for energy fuel used in heating and cooling.

    a. Watt
    b. Kilowatt
    c. British Thermal Unit (Btu)
    d. Cubic foot (CFM)

3. Define terms related to heating and cooling fundamentals:

    a. Heat Load
    b. Heat Gain
    c. Cooling Load
    d. Tons of Refrigeration
    e. Energy Efficiency Ratio
    f. Temperature Difference
    g. Summer Design Temperature
    h. Winter Design Temperature
    i. Inside Temperature
    j. Relative Humidity
    k. Humidifier
    l. Dehumidifier
    m. Ventiliation
    n. Infiltration

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

UNIT I

FUNDAMENTALS OF HEATING AND COOLING

LECTURE | ACTIVITIES

FUNDAMENTALS OF HEATING AND COOLING

INTRODUCTION

Non-renewable energy (coal, gas, and oil) is used in homes. Due to diminishing supplies, curtailments, and real or fabricated shortages, energy prices are rising; in no area does a household experience this more than in heating and cooling bills. As shown in Figure 1.1, 15.7 percent of the total U.S. energy budget is devoted to heating (space and water) and cooling (air conditioning and refrigeration). When searching for ways to simplify lifestyles, there is no better place to start than with air conditioning.

Efficiency can be maximized by insulating homes and offices, as discussed in Module #8. Keeping our heating and cooling systems in proper working order will also cut costs. Energy- wasteful appliances can be operated only when absolutely necessary and at non-peak load hours; (see Module #7) and everyone should practice conservation measures, such as using hot water sparingly (Module #6).

FIGURE 1.1

ENERGY USE
PERCENT OF TOTAL U.S. ENERGY USE
IN RESIDENTIAL SECTOR

WOOD	NIL
COAL	NIL
NATURAL GAS	7.3%
ELECTRICITY	7.5%
OIL	4.4%
TOTAL	19.2%

SPACE HEATING	11.0%	15.7%
WATER HEATING	2.9%	
AIR CONDITIONING	0.7%	
REFRIGERATION	1.1%	
COOKING	1.1%	
LIGHTING	0.7%	
OTHER (SMALL APPLIANCES)	1.7%	
TOTAL	19.2%	

This unit will discuss the design, installation, and proper use of space heating and cooling systems for the home and will touch on energy saving tips for the consumer. Once a basic house is designed to include amounts of insulation, types and sizes of windows, size and shape of the house, orientation, etc. (Module #8), the homeowner must then determine the heat loss and heat gain requirement of a building so that a balance between the two can be obtained by properly adding air conditioning (see Module #8). This is one of the most important considerations in examining energy use and energy abuse in a home.

The first step in reducing energy consumption and fuel bills is understanding some of the basic principles of heating and cooling. Most energy consumed in the home is through the operation of furnaces, air conditioners, ovens, and refrigerators. By understanding how heating and cooling take place, one can gain a real insight into the factors that make these units work efficiently.

First, remember that the total heating or cooling bill depends upon two factors: (1) the efficiency of a furnace, air conditioner, or other appliances, and, (2) the amount of work it is asked to do. Efficiency is a measure of how much energy is actually used in doing a particular job; 100% efficiency means no wasted energy, while 50% means half is wasted. A fact too often ignored is the actual amount of work required to do the job. A poorly insulated house requires far more energy to heat and cool than does a well insulated house. Sealing air leaks, adding insulation, and doing other simple jobs can do far more to reduce fuel

Discuss the following terms:

Thermostat

bills than buying the most sophisticated, expensive, high-efficiency furnace or cooler on the market.

Many homes today have fully controlled temperatures year around. In winter, the home is heated by a furnace; in summer, it is cooled by an air conditioner. The inside temperature is regulated by a thermostat. Although there are many different types, brands, and models of heating and cooling equipment, the basic purpose is the same--to keep the occupants comfortable--neither too hot nor too cold.

Heating and cooling a home costs money. Electricity is consumed, gas and oil are burned, and the occupant must pay for what is used. The object,then, is to use as little energy as possible to heat and cool the home. Using efficient equipment is one way to cut down energy consumption, and adding insulation is another. (Adding insulation is discussed in Module #8.) Efficient equipment makes it possible to use energy in the least wasteful manner, while insulation slows down the escape of heat energy in the winter and the entrance of heat in the summer.

A. ENERGY UNITS

Energy Units refers something bought in measured amounts. Different kinds of energy come in different forms and are measured in different units. For example, one buys natural gas by the cubic foot, gasoline and fuel oil by the gallon, and coal by the ton. But energy consumption does not take place instantly--time is required to use up the fuel.

Measuring electrical energy is sometimes confusing because it cannot be measured in a unit or quantity that one can see. Electrical appliances are rated in watts, which indicate the amount of power consumed, but power and energy are not the same. The electric meter records energy consumption in watt-hours or kilowatt-hours. (The prefix kilo means 1,000, so a kilowatt is 1,000 watts) In other words, energy is equal to the product of power and time. If a 100-watt light bulb burns for one hour, 100 watt-hours of electrical energy are consumed (E=P+T). If the same bulb burns for two hours, it would have consumed 200 watthours, or 0.2 kilowatt-hours will be consumed. If the electric power company charges 5 cents per kilowatt-hour, then 0.2 KWH would cost 0.2 X 5 = 1 cent.

The British thermal unit (Btu) is the basic unit used in measuring heat energy, and the energy capacity of both heating and cooling equipment is measured with this unit. For example, a moderate-sized home in a northern state might have a furnace rated at 100,000 Btu and a cooling unit rated at 36,000 Btu. The furnace is rated on the basis of how much heat it can deliver to the house, while the cooling unit is rated by how much heat it can remove from the house. As these figures indicate, one Btu represents a fairly small amount of heat energy. Technically speaking, a Btu is the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit. However, this unit is easier to visualize by thinking of a Btu as being about equal to the heat delivered in one hour by the flame of one candle on a birthday cake. The one hour refers to the heat output of the candle which is actually one Btu per hour.

Home heating requirements are also figured in Btu. The heat load is the amount of heat that escapes from the structure through--walls, windows, doors, ceilings, floors, etc. If a house has a 100,000 Btu heat load (figured on the coldest expected temperature), it will require a furnace with at least 100,000 Btu capacity to heat the home.

When air-conditioning a home, the terms heat gain or cooling load are used to specify the amount of heat that must be removed from the home. A home having a summer heat gain of 36,000 Btu (figured on the hottest typical day) would require an air conditioner rated at 36,000 Btu. This cooling capacity is easily accomplished with a moderately sized central unit, or several smaller window-mounted units totaling 36,000 Btu.

Larger air conditioners are normally measured in tons of refrigeration, which has nothing to do with the air conditioner's actual weight. In this system, one ton of cooling capacity corresponds to 12,000 Btu. Thus, a 36,000 Btu air conditioner could also be rated as a 3-ton air conditioner. The ton unit came about in the early "icebox" days of refrigeration because it represented the amount of heat energy required to melt one ton of ice in 24 hours.

Since the Btu and the watt-hour are both units of heat energy, a simple conversion factor can be used to relate them. One watt-hour is roughly 3.4 Btu. Similarly, one kilowatt-hour is about 3,400 Btu.

Discuss the meaning of these terms:

Watt

Kilowatt

British Thermal Unit

Heat Load

Heat Gain

Cooling Load

Tons of Refrigeration

Energy Efficiency Ratio

Temperature Difference

Inside Temperature

Relative Humidity

Humidifier

Dehumidifier

Ventilation

Infiltration

To convert watts to Btu, simply multiply the number of watts by 3.4. Alternatively, to convert Btu to watts, divide the Btu rating by 3.4. Electrical heating equipment is sometimes sized in watts instead of Btu, particularly with baseboard heaters and space heaters.

The energy efficiency ratio (EER) is a handy way to compare the efficiencies of various air conditioners. The EER is equal to the Btu rating divided by the input watts. Air coolers do not produce heat directly; instead, they merely transfer, or pump, heat energy from one place to another. In a refrigerator, for instance, the motor pumps Freon gas through coils located both inside and outside of the refrigerator. One coil absorbs and removes heat energy from the inside, thus making it cold, while the second coil dissipates the heat into the outside air circulating over its fins. The advantage is that less energy is required to pump heat than to generate it, as in a heater. This is proven by the fact that typical conditioners with an EER between 5 and 10, and that typical air conditioner is capable of removing about 25 times as much heat energy from the home as the unit itself consumes in electrical energy.

The EER for an air conditioner is determined under prescribed test conditions of temperature and humidity, and this is done so that one can easily compare the performance of all cooling units. But it must be pointed out that outside temperature will vary while the unit is actually in operation, thus influencing the efficiency with which an air conditioner can pump heat out of the house. The official EER rating reflects a typical summer operating condition: however, one can expect that an air conditioner will use more electrical energy on extremely hot days and less on cooler days.

B. TEMPERATURE DIFFERENCES

Temperatures are generally measured in degrees Fahrenheit in the U.S. although the metric Celsius (or centigrade) scale--used almost everywhere else in the world--is catching up with us. On the Celsius scale, 0°C (212°F) represents the boiling point of water. In terms of room temperature, 20°C (68°F) is just a bit on the chilly side, while 25°C (77°F) is just a bit on the warm side. Throughout this book temperatures will be given in Fahrenheit unless otherwise noted.

The temperature difference is the difference between the inside and outside temperatures of a building. As the temperature difference increases, the heat load or cooling load also increases. Consequently, more fuel will be required to heat a house when the difference between the inside and outside temperature is 70 degrees than when the temperature difference is only 30 degrees.

Design temperatures vary according to location in the nation. The winter design temperature tells how cold it will usually get in an area. This will determine the heat load of the home and, therefore, the size of the required heating unit. For example, the winter design temperature in Milwaukee, Wisconsin is -17°F. The temperature difference for a home in Milwaukee with its thermostat set at 63°F would then be 85 degrees. Similarly, the winter design temperature in Jacksonville, Florida is 33°F, so for the same thermostat setting, the Milwaukee home would require a much larger heating unit than an identical home in Jacksonville.

Figure 1.2 gives a sample of design temperature for heating.

DESIGN TEMPERATURES FOR HEATING

The following table lists the outdoor winter temperatures in common use in these areas. These are recommended for use as the basis for preparing heating estimates.

State & City	Design Temp. F
ALABAMA	
Anniston	10
Birmingham	10
Gadsden	10
Mobile	20
Montgomery	20
Tuscaloosa	10
ALASKA	
Anchorage	-24
Barrow	-48
Bethel	-43
Cordova	-13
Fairbanks	-57
Juneau	-5
Ketchikan	4
Kodiak	4
Kotzebue	-46
Nome	-36
Seward	-4
Sitka	2
ARIZONA	
Bisbee	30
Flagstaff	-5
Globe	30
Nogales	30
Phoenix	35
Tucson	30
Winslow	-5
Yuma	40
ARKANSAS	
Bentonville	0
Fort Smith	5
Hot Springs	10
Little Rock	10
Pine Bluff	10
Texarkana	10
CALIFORNIA	
Bakersfield	30
El Centro	35
Eureka	30
Fresno	30
Long Beach	35
Los Angeles	40
Montague	15
Needles	25
Oakland	30
Pasadena	40
Red Bluff	15
Sacremento	30
San Bernardino	30
San Diego	45
San Francisco	35
San Jose	40
COLORADO	
Boulder	-15
Colorado Springs	-10
Denver	-10
Durango	-5
Fort Collins	-15
Grand Junction	-5
Leadville	-10
Pueblo	-15
CONNECTICUT	
Bridgeport	0
Hartford	0
New Haven	0
New London	5
Norwalk	0
Torrington	0
Waterbury	0
DELAWARE	
Dover	10
Milford	10
Wilmington	5
DIST. OF COLUMBIA	
Washington	10
FLORIDA	
Apalachicola	25
Fort Myers	40
Gainesville	30
Jacksonville	30
Key West	55
Miami	45
Orlando	35
Pensacola	25
Tallahassee	25
Tampa	35
GEORGIA	
Athens	10
Atlanta	10
Augusta	20
Brunswick	25
Columbus	20
Macon	20
Rome	10
Savannah	25
Way Cross	25
IDAHO	
Boise	-10
Idaho Falls	-15
Lewiston	-10
Pocatello	-15
Twin Falls	-15
ILLINOIS	
Aurora	-10
Bloomington	-10
Cairo	0
Champaign	-10
Chicago	-10
Danville	-10
Decatur	-10
Elgin	-15
Joliet	10
Moline	-10
Peoria	-15
Rockford	-15
Rock Island	-10
Springfield	-10
Urbana	-10
INDIANA	
Elkhart	-10
Evansville	-5
Fort Wayne	-5
Indianapolis	-10
Lafayette	-10
South Bend	-10
Terre Haute	-5
IOWA	
Burlington	10
Cedar Rapids	-15
Charles City	-20
Clinton	-15
Council Bluffs	-15
Davenport	-10
Des Moines	15
Dubuque	-15
Fort Dodge	-15
Keokuk	-15
Marshalltown	-15
Sioux City	-15
Waterloo	-15
KANSAS	
Atchison	10
Concordia	-10
Dodge City	10
Iola	5
Leavenworth	10
Salina	-10
Topeka	-10
Wichita	-5
KENTUCKY	
Bowling Green	0
Frankfort	0
Hopkinsville	0
Lexington	0
Louisville	0
Owensboro	0
Shelbyville	0
LOUISIANA	
Alexandria	20
Baton Rouge	20
New Orleans	25
Shreveport	15
MAINE	
Augusta	-15
Bangor	-20
Bar Harbor	-10
Belfast	-10
Eastport	-10
Lewiston	-10
Millinocket	-15
Orono	-20
Portland	-10
Presque Isle	-20
Rumford	-15
MARYLAND	
Annapolis	10
Baltimore	10
Cambridge	10
Cumberland	0
Frederick	5
Frostburg	-5
Salisbury	10
MASSACHUSETTS	
Amherst	-5
Boston	0
Fall River	0
Fitchburg	-5
Framingham	-5
Lawrence	-5
Lowell	-5
Nantucket	0
New Bedford	0
Pittsfield	-10
Plymouth	0
Springfield	-5
Worcester	-5
MICHIGAN	
Alpena	-10
Ann Arbor	-5
Big Rapids	-5
Cadillac	-10
Calumet	-20
Detroit	-5
Escanaba	-20
Flint	-10
Grand Haven	-5
Grand Rapids	-5
Houghton	-20
Kalamazoo	-5
Lansing	10
Ludington	-5
Marquette	-15
Muskegon	5
Port Huron	-10
Saginaw	10
Sault Ste. Marie	20
MINNESOTA	
Alexandria	-25
Duluth	-25
Minneapolis	-25
Moorhead	-30
St. Cloud	-25
St. Paul	-25
MISSISSIPPI	
Biloxi	25
Columbus	10
Corinth	5
Hattiesburg	20
Jackson	15
Meridian	15
Natchez	15
Vicksburg	15
MISSOURI	
Columbia	-10
Hannibal	-10
Kansas City	-10
Kirksville	-10
St. Joseph	-10
St. Louis	-5
Springfield	-5
MONTANA	
Anaconda	-30
Billings	-30
Butte	-30
Great Falls	-40
Havre	-40
Helena	-40
Kalispell	-30
Miles City	-35
Missoula	-30
NEBRASKA	
Grand Island	-15
Hastings	-15
Lincoln	-15
Norfolk	-15
North Platte	-15
Omaha	-15
Valentine	-20
York	-15
NEVADA	
Elko	-10
Las Vegas	10
Reno	5
Tonopah	5
Winnemucca	-10
NEW HAMPSHIRE	
Berlin	-15
Claremont	-15
Concord	-10
Franklin	-15
Hanover	-15
Keene	-10
Manchester	-10
Nashua	-10
Portsmouth	-5
NEW JERSEY	
Asbury Park	5
Atlantic City	10
Bayonne	0
Belvidere	0
Bloomfield	0
Bridgeton	5
Camden	5
East Orange	0
Elizabeth	0
Jersey City	0
Newark	0
New Brunswick	5
Paterson	0
Phillipsburg	0
Trenton	0
NEW MEXICO	
Albuquerque	10
El Morro	0
Raton	-5
Roswell	5
Santa Fe	5
Tucumcari	5
NEW YORK	
Albany	-10
Auburn	-10
Binghamton	-5
Buffalo	-5
Canton	-20
Cortland	-10
Elmira	-5
Glens Falls	-15
Ithaca	5
Jamestown	5
Lake Placid	-15
New York	5
Niagara Falls	5
Ogdensburg	20
Oneonta	-10
Oswego	5
Port Jervis	0
Rochester	-5
Schenectady	10
Syracuse	-10
Watertown	-15
NORTH CAROLINA	
Asheville	5
Charlotte	15
Greensboro	10
Hatteras	20
New Bern	20
Raleigh	15
Salisbury	10
Wilmington	20
Winston-Salem	10
NORTH DAKOTA	
Bismarck	-30
Devils Lake	-30
Dickinson	-30
Fargo	-30
Grand Forks	-30
Jamestown	-30
Minot	-35
Pembina	-35
Williston	-35
OHIO	
Akron	-5
Cincinnati	-5
Cleveland	-5
Columbus	-5
Dayton	-5
Lima	-5
Marion	-5
Sandusky	-5
Toledo	-5
Warren	-5
Youngstown	-5
OKLAHOMA	
Ardmore	5
Bartlesville	-5
Guthrie	0
Muskogee	0
Oklahoma City	0
Tulsa	0
Waynoka	-5
OREGON	
Arlington	5
Baker	-15
Eugene	15
Medford	20
Pendleton	-10
Portland	10
Roseburg	20
Salem	15
Wamic	0
PENNSYLVANIA	
Altoona	-5
Bethlehem	0
Coatesville	5
Erie	-5
Harrisburg	5
New Castle	-5
Oil City	-5
Philadelphia	5
Pittsburgh	-5
Reading	5
Scranton	0
Warren	-5
Williamsport	5
York	5
RHODE ISLAND	
Block Island	5
Bristol	0
Kingston	0
Pawtucket	0
Providence	0
SOUTH CAROLINA	
Charleston	20
Columbia	20
Florence	20
Greenville	10
Spartanburg	10
SOUTH DAKOTA	
Aberdeen	-25
Huron	-20
Pierre	-20
Rapid City	-20
Sioux Falls	-20
Watertown	-25
TENNESSEE	
Chattanooga	10
Jackson	5
Johnson City	0
Knoxville	5
Memphis	5
Nashville	5
TEXAS	
Abilene	5
Amarillo	0
Austin	15
Brownsville	30
Corpus Christi	25
Dallas	10
Del Rio	20
El Paso	20
Fort Worth	10
Galveston	25
Houston	20
Palestine	10
Port Arthur	20
San Antonio	20
Waco	10
UTAH	
Logan	-10
Milford	-5
Ogden	-5
Salt Lake City	0
VERMONT	
Bennington	-10
Burlington	-15
Montpelier	-20
Newport	-20
Northfield	-20
Rutland	-15
VIRGINIA	
Cape Henry	15
Charlottesville	10
Danville	10
Lynchburg	10
Norfolk	15
Petersburg	10
Richmond	10
Roanoke	5
Wytheville	5
WASHINGTON	
Aberdeen	20
Bellingham	10
Everett	15
North Head	20
Olympia	15
Seattle	15
Spokane	-15
Tacoma	15
Tatoosh Island	20
Walla Walla	-10
Wenatchee	-10
Yakima	-5
WEST VIRGINIA	
Bluefield	0
Charleston	0
Elkins	-5
Fairmont	0
Huntington	0
Martinsburg	0
Parkersburg	0
Wheeling	-5
WISCONSIN	
Ashland	-25
Beloit	-15
Eau Claire	-20
Green Bay	-20
La Crosse	-20
Madison	-20
Milwaukee	-15
Oshkosh	-20
Sheboygan	-20
WYOMING	
Casper	-25
Cheyenne	-20
Lander	-30
Sheridan	-30
Yellowstone Park	-35

FIGURE 1.2

Summer design temperatures also vary according to location. The summer design temperature tells how hot it is expected to get in the summer. In Milwaukee the summer design temperature is 95°F, while in Jacksonville it is 104°F. The cooling units used in these areas must be sized according to the summer design temperatures.

Figure 1.3 shows the design temperature for cooling.

The inside temperature in a home is regulated by using heating and cooling equipment. However, the inside temperature also affects the temperature difference between the inside and outside of the house. Thus the setting of the thermostat changes the heating and cooling load of the home. Lowering the thermostat in the winter lowers the heat load of the home, meaning that less energy is consumed by the furnace in maintaining the home at the desired temperature. Raising the inside temperature of the home during the summer means that the cooling load is reduced and the air conditioner doesn't have to work as hard.

A point to remember is that the heating and cooling loads for a home will not be the same because different temperatures are involved. A house with a heat load of 80,000 Btu will not have a cooling load of 80,000 Btu except possibly in some southern states. In a typical northern state, the house might have an 80,000 Btu heat load and a 36,000 Btu cooling load. The difference in heating and cooling loads results because the loads are figured using different design temperatures and inside temperatures, and also because they include solar heating effects due to sunlight. The heating and cooling loads in areas can be found for almost any structure by using charts and tables designed for that very purpose.

DESIGN TEMPERATURES FOR AIR CONDITIONING

(OUTSIDE DRY- AND WET-BULB TEMPERATURES)

State & City	Summer DB	Summer WB
ALABAMA		
Anniston	95	78
Birmingham	95	78
Gadsden	95	78
Mobile	90	80
Montgomery	95	78
Tuscaloosa	95	78
ARIZONA		
Bisbee	100	72
Flagstaff	85	61
Globe	105	76
Nogales	105	72
Phoenix	105	76
Tucson	100	72
Winslow	95	65
Yuma	110	78
ARKANSAS		
Bentonville	95	76
Fort Smith	95	76
Hot Springs	95	78
Little Rock	95	78
Pine Bluff	95	78
Texarkana	100	78
CALIFORNIA		
Bakersfield	105	70
El Centro	110	78
Eureka	90	65
Fresno	105	74
Long Beach	90	70
Los Angeles	90	70
Montague	95	70
Needles	115	—
Oakland	80	65
Pasadena	95	70
Red Bluff	100	70
Sacramento	100	72
San Bernardino	105	72
San Diego	80	68
San Francisco	80	65
San Jose	90	70
COLORADO		
Boulder	95	64
Colorado Springs	95	65
Denver	95	64
Durango	95	65
Fort Collins	95	65
Grand Junction	95	65
Leadville	95	64
Pueblo	95	65
CONNECTICUT		
Bridgeport	85	75
Hartford	90	75
New Haven	85	75
New London	85	75
Norwalk	85	75
Torrington	90	75
Waterbury	90	75
DELAWARE		
Dover	90	78
Milford	90	78
Wilmington	90	78
DIST. OF COLUMBIA		
Washington	90	78
FLORIDA		
Apalachicola	95	80
Fort Myers	95	78
Gainesville	95	78
Jacksonville	95	78
Key West	100	78
Miami	90	79
Orlando	90	78
Pensacola	95	78
Tallahassee	95	78
Tampa	95	78
GEORGIA		
Athens	95	76
Atlanta	95	76
Augusta	100	76
Brunswick	95	78
Columbus	100	76
Macon	95	78
Rome	95	76
Savannah	95	78
Way Cross	95	78
IDAHO		
Boise	95	65
Idaho Falls	90	65
Lewiston	95	65
Pocatello	90	65
Twin Falls	95	65
ILLINOIS		
Aurora	95	75
Bloomington	95	76
Cairo	100	78
Champaign	95	77
Chicago	95	75
Danville	95	77
Decatur	95	77
Elgin	95	78
Joliet	95	76
Moline	95	76
Peoria	95	76
Rockford	96	78
Rock Island	95	76
Springfield	95	77
Urbana	95	77
INDIANA		
Elkhart	95	75
Evansville	95	78
Fort Wayne	95	75
Indianapolis	95	76
Lafayette	95	76
South Bend	95	75
Terre Haute	95	78
IOWA		
Burlington	95	78
Cedar Rapids	95	78
Charles City	95	75
Clinton	95	78
Council Bluffs	100	78
Davenport	95	78
Des Moines	95	78
Dubuque	95	78
Fort Dodge	95	78
Keokuk	95	78
Marshalltown	95	78
Sioux City	95	78
Waterloo	95	78
KANSAS		
Atchison	100	76
Concordia	95	78
Dodge City	95	78
Iola	100	75
Leavenworth	100	76
Salina	100	78
Topeka	100	78
Wichita	100	75
KENTUCKY		
Bowling Green	95	78
Frankfort	95	78
Hopkinsville	95	78
Lexington	95	78
Louisville	95	78
Owensboro	95	78
Shelbyville	95	78
LOUISIANA		
Alexandria	95	78
Baton Rouge	95	80
New Orleans	95	80
Shreveport	95	78
MAINE		
Augusta	85	73
Bangor	85	73
Bar Harbor	85	73
Belfast	85	73
Eastport	85	70
Lewiston	85	73
Millinocket	85	73
Orono	85	70
Portland	85	73
Presque Isle	85	73
Rumford	85	73
MARYLAND		
Annapolis	90	78
Baltimore	90	78
Cambridge	90	78
Cumberland	90	75
Frederick	90	78
Frostburg	90	75
Salisbury	90	78
MASSACHUSETTS		
Amherst	90	75
Boston	85	74
Fall River	85	75
Fitchburg	90	75
Framingham	85	75
Lawrence	85	74
Lowell	85	74
Nantucket	85	75
New Bedford	85	75
Pittsfield	90	75
Plymouth	85	75
Springfield	90	75
Worcester	90	75
MICHIGAN		
Alpena	90	75
Ann Arbor	90	76
Big Rapids	90	75
Cadillac	90	75
Calumet	80	73
Detroit	90	75
Escanaba	85	74
Flint	90	75
Grand Haven	90	75
Grand Rapids	90	74
Houghton	80	73
Kalamazoo	90	75
Lansing	90	75
Ludington	90	75
Marquette	80	73
Muskegon	90	74
Port Huron	90	75
Saginaw	90	75
Sault Ste. Marie	80	71
MINNESOTA		
Alexandria	85	74
Duluth	80	71
Minneapolis	90	76
Moorhead	95	75
St. Cloud	90	76
St. Paul	90	75
MISSISSIPPI		
Biloxi	90	80
Columbus	95	78
Corinth	95	78
Hattiesburg	95	80
Jackson	95	78
Meridian	95	79
Natchez	95	78
Vicksburg	95	78
MISSOURI		
Columbia	100	78
Hannibal	95	77
Kansas City	100	76
Kirksville	95	78
St. Joseph	100	76
St. Louis	95	78
Springfield	100	77
MONTANA		
Anaconda	85	59
Billings	90	66
Butte	85	59
Great Falls	90	63
Havre	95	70
Helena	90	63
Kalispell	90	63
Miles City	95	69
Missoula	90	63
NEBRASKA		
Grand Island	100	75
Hastings	100	75
Lincoln	95	78
Norfolk	95	78
North Platte	100	73
Omaha	100	78
Valentine	95	78
York	95	78
NEVADA		
Elko	95	63
Las Vegas	110	71
Reno	95	65
Tonopah	90	63
Winnemucca	95	65
NEW HAMPSHIRE		
Berlin	85	73
Claremont	85	73
Concord	85	73
Franklin	85	73
Hanover	85	73
Keene	85	73
Manchester	85	74
Nashua	85	74
Portsmouth	85	74
NEW JERSEY		
Asbury Park	90	78
Atlantic City	90	78
Bayonne	90	75
Belvidere	90	75
Bloomfield	90	75
Bridgeton	90	78
Camden	90	78
East Orange	90	75
Elizabeth	90	75
Jersey City	90	75
Newark	90	76
New Brunswick	90	75
Paterson	90	75
Phillipsburg	90	75
Trenton	90	78
NEW MEXICO		
Albuquerque	95	65
El Morro	85	65
Raton	95	65
Roswell	100	71
Santa Fe	90	65
Tucumcari	95	70
NEW YORK		
Albany	90	74
Auburn	90	74
Binghamton	90	72
Buffalo	85	73
Canton	85	73
Cortland	90	74
Elmira	90	73
Glens Falls	90	73
Ithaca	90	73
Jamestown	90	74
Lake Placid	90	73
New York	90	76
Niagara Falls	85	73
Ogdensburg	85	73
Oneonta	90	73
Oswego	90	74
Port Jervis	90	75
Rochester	90	74
Schenectady	90	74
Syracuse	90	74
Watertown	85	73
NORTH CAROLINA		
Asheville	90	75
Charlotte	95	78
Greensboro	90	76
Hatteras	90	80
New Bern	95	78
Raleigh	95	78
Salisbury	90	78
Wilmington	90	81
Winston-Salem	90	76
NORTH DAKOTA		
Bismarck	95	73
Devils Lake	90	70
Dickinson	95	70
Fargo	95	75
Grand Forks	90	72
Jamestown	95	73
Minot	90	71
Pembina	90	73
Williston	90	73
OHIO		
Akron	90	75
Cincinnati	95	78
Cleveland	90	75
Columbus	90	76
Dayton	90	76
Lima	90	75
Marion	90	75
Sandusky	90	75
Toledo	90	75
Warren	90	75
Youngstown	90	75
OKLAHOMA		
Ardmore	100	78
Bartlesville	100	77
Guthrie	100	77
Muskogee	95	79
Oklahoma City	100	77
Tulsa	100	77
Waynoka	105	75
OREGON		
Arlington	95	68
Baker	90	66
Eugene	90	68
Medford	95	68
Pendleton	90	66
Portland	85	68
Roseburg	90	66
Salem	90	68
Wamic	90	66
PENNSYLVANIA		
Altoona	90	75
Bethlehem	90	75
Coatesville	90	75
Erie	85	74
Harrisburg	90	75
New Castle	90	75
Oil City	90	[illegible]
Philadelphia	90	78
Pittsburgh	90	75
Reading	90	75
Scranton	90	75
Warren	90	75
Williamsport	90	74
York	90	75
RHODE ISLAND		
Block Island	85	75
Bristol	90	75
Kingston	85	75
Pawtucket	90	75
Providence	90	75
SOUTH CAROLINA		
Charleston	90	80
Columbia	95	78
Florence	95	79
Greenville	95	75
Spartanburg	95	78
SOUTH DAKOTA		
Aberdeen	95	75
Huron	100	75
Pierre	95	73
Rapid City	95	70
Sioux Falls	95	75
Watertown	95	73
TENNESSEE		
Chattanooga	95	76
Jackson	95	78
Johnson City	95	78
Knoxville	95	75
Memphis	95	78
Nashville	95	78
TEXAS		
Abilene	95	74
Amarillo	95	72
Austin	100	78
Brownsville	95	80
Corpus Christi	95	80
Dallas	100	78
Del Rio	100	78
El Paso	100	69
Fort Worth	100	78
Galveston	95	80
Houston	95	80
Palestine	100	78
Port Arthur	95	80
San Antonio	100	78
Waco	100	78
UTAH		
Logan	95	65
Milford	95	66
Ogden	90	65
Salt Lake City	95	65
VERMONT		
Bennington	90	73
Burlington	90	73
Montpelier	90	73
Newport	85	73
Northfield	90	73
Rutland	90	73
VIRGINIA		
Cape Henry	90	78
Charlottesville	90	78
Danville	90	78
Lynchburg	90	76
Norfolk	90	78
Petersburg	90	78
Richmond	90	78
Roanoke	90	76
Wytheville	90	76
WASHINGTON		
Aberdeen	85	64
Bellingham	80	65
Everett	80	65
North Head	80	65
Olympia	80	64
Seattle	80	65
Spokane	80	65
Tacoma	80	64
Tatoosh Island	80	65
Walla Walla	90	65
Wenatchee	90	65
Yakima	90	67
WEST VIRGINIA		
Bluefield	95	75
Charleston	90	75
Elkins	90	74
Fairmont	90	75
Huntington	90	76
Martinsburg	90	75
Parkersburg	90	75
Wheeling	90	75
WISCONSIN		
Ashland	80	71
Beloit	95	78
Eau Claire	90	[illegible]
Green Bay	90	74
La Crosse	95	75
Madison	90	75
Milwaukee	90	75
Oshkosh	90	75
Sheboygan	90	75
WYOMING		
Casper	90	62
Cheyenne	90	62
Lander	90	65
Sheridan	90	65
Yellowstone Park	85	62

FIGURE 1.3

The heating and cooling loads--and hence fuel bills--are also affected by what is inside the building. Appliances such as stoves, toasters, irons, ovens, washers, and dryers produce heat. Lamps, in addition to giving light, also contribute heat. People, whether sitting or actively moving about, also generate varying amounts of body heat. In winter, this extra heat is welcomed because it lowers the heating load, but in summer this extra heat places an added burden on the airconditioning system that must remove it.

C. HUMIDITY

Humidity refers to the amount of water vapor or moisture in the air. Warm air can hold more water vapor than cool air, so warm air speeds up evaporation. Relative humidity is a way of expressing the percentage of moisture contained in the air at a specific temperature. For example, 50% relative humidity means that the air is holding only half as much moisture as it is capable of holding at that temperature. Raising or lowering the temperature will change the relative humidity. In a sealed house, as the temperature rises, the relative humidity decreases; and as the temperature falls, the relative humidity increases. If the temperature falls enough (as when the air circulates over a cold beverage glass), the relative humidity reaches 100% and water begins to condense out of the air, forming drops of water on the glass.

High humidity and condensation can be undesirable in a home, making the air feel clammy, rotting window moldings, and rusting tools and equipment. On the other hand, low humidity makes the air feel dry, increases static electricity, and causes wood to dry and shrink. Consequently, both humidifiers and dehumidifiers are often used in homes to control the relative humidity to within comfortable limits.

Since air conditioners also dehumidify the air by condensing and removing water vapor, it is desirable to select a unit with the right cooling capacity to properly control both the humidity and temperature of the home. (Refer to Module #9 for a discussion of relative humidity, wet bulb temperatures, dry bulb temperatures, and human comfort zones.)

The motion of the air in a home plays many important roles. Too much air motion can make a home feel drafty, while too little air motion prevents uniform heating and cooling of the air. Air coming into the house from outside, and the subsequent loss of air from inside, is also a major source of heat loss and heat gain. Sometimes, this outside air is desirable, sometimes not. Fresh air can supply oxygen and remove stale odors, but most homes ordinarily have enough air entering through opening and closing of doors so no additional air is needed. In general, air movement into and out of a home can occur in two different ways: ventilation and infiltration.

Ventilation occurs when air is intentionally brought into the home and made to mix with the air in the building. Ventilation air can be brought in by a separate fan, or it can be introduced using a special vent connected in the duct system. In either case, it is necessary to control not only the amount of outside air brought in but its temperature as well.

Many buildings are required by law or local building codes to have a certain amount of outside ventilation, especially nursing homes, hospitals, factories, and office buildings. The purpose of this ventilation air is to mix fresh air with circulating air in order to reduce the amount of odors, bacteria, and noxious gases. Ventilation air also insures that an acceptable level of oxygen is present in the air.

The average home, though, does not need to have outside air brought in. The attic and crawl space, however, do require ventilation. Attic space usually needs ventilation all year round to remove heat buildup in summer and moisture in winter. The crawl space needs venting in the summer to remove moisture that would rot beams and produce musty odors. Such ventilation is not usually desirable in winter because it increases the heat load and results in cold floors.

Ventilation in the furnace room is sometimes required by insurance and loan companies. This requirement is intended to prevent the furnace from burning up all the oxygen in the house. The furnace room is thus equipped with an outside vent to provide fresh air to the furnace burners, and combustion gases are then exhausted safely up the chimney. In many European countries, the vent is opened and closed automatically to increase furnace efficiency, but at present this scheme is not approved in the U.S.

Infiltration air enters the home through cracks around windows and tiny openings in walls, ceilings, and floors. Hearing whistling noises around doors and windows while the wind is blowing hard is listening to infiltration air. The same is true when window shades and blinds move as the wind blows outside. This infiltration air is not intentional--a perfectly sealed home would not have any such movement. Since infiltration air must be heated and cooled, it contributes to the heating and cooling load of the home.

Heat energy is moved or transferred from one place to another by three major methods: convection, conduction, and radiation (for a thorough discussion of these principles, refer to Module #8).

D. SUMMARY

By putting these terms into practice, the homeowner becomes aware of how the home is conditioned year around. The harmonious balance of factors in home conditioning produces the most efficiency for the energy used, and expends no more work load than is needed.

MODULE X

HEATING, VENTILATING, AND AIR CONDITION CONSERVATION OPPORTUNITIES

UNIT II

HEATING SYSTEMS

UNIT OBJECTIVES

1. Identify the components of a forced air heating system.
2. Calculate heat loss in a home.
3. Size a heating system for a particular home heating need.
4. Explain the difference in fuel costs among energy fuels available for heating use.
5. Recognize and implement measures to improve energy efficiency in heating systems.
6. Discuss differences in efficiency among gas, oil, electric, and heat pump central systems, and baseboard and space heaters.
7. Discuss maintenance measures for heating systems.
8. Discuss the role of humidifiers in heating a home.

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

UNIT II

HEATING SYSTEMS

LECTURE

INTRODUCTION:

Unless a heating system is operating at maximum efficiency, money is lost. Any time a furnace is out of adjustment or the air circulation is restricted, the heating efficiency is reduced and the operating cost is increased. Once it is understood how a heating system works and how to size a unit for a particular need, it will be easy to correct and even anticipate common problems that affect heating system efficiency.

A. FORCED AIR COMPONENTS

A central heating system consists of a furnace, which serves as the source of heat; a fan, to distribute the heated air; and ductwork, to provide a path by which the air travels. Figure 2.1 illustrates how a forced air system operates in prinicple.

All forced air systems operate similarly...and automatically. When room temperature drops below a pre-determined minimum setting of the thermostat (A), the burner (B) starts, and heats the air around the heat exchanger (C) in the furnace. When the temperature of the air in the furnace reaches the "fan on" setting of the fan control, the furnace blower (D) starts. The blower pulls the cool air from the rooms through the grilles (E) and return-air ducts (F) to the furnace. Here, the air

ACTIVITIES

ACTIVITY

An interesting activity for students is to have them look at the effects on efficiency of changing flow rates. This can be done by partially blocking a return air duct or partially blocking or shutting the vents on a heat duct. In this case, the student should have the system clean and open and do a temperature vs. time measurement on the heating of a room with the vents open and partially closed, or blocked completely. When a student has part of the return duct closed, a timing should be done on how long it takes the furnace system to cycle on and off, and how often it comes back on. These experiments will show how much less the efficiency and cycle time is for a furnace which has lower reduced rates of flow, or which is partly blocked. In addition, filters are extremely important to the intake of the furnace. Dust in a fine layer is a very good insulating material. Dust allowed to build up inside the pipes is essentially blocking the inside of the pipes and the heat exchanger. Dust in the outer pipes may be slightly insulative but it usually is deposited in the furnace first and will reduce the plenum's efficiency or heat transfer. Also, the fine dust increases the amount of cleaning, the amount of traffic, and the amount of dirt that is in the air.

passes through the filters (G), and circulates around the heat exchanger where it warms and picks up moisture from the humidifier (H). The cleaned, moistened, and warmed air is then delivered to the registers (I) in each room through the warm-air ductwork (J). When the thermostat is satisfied, the burner automatically shuts off. The fan control should be set so that the blower runs almost continuously during cold weather. Cost of continuous blower operation is little more than for intermittent operation, and gives more comfortable, uniform heating with little chance of air stratification. A control automatically turns off the burner if the furnace overheats.

B. SIZING A HEATING SYSTEM

Once a house is designed to include insulation, types and sizes of windows, size and shape of house, orientation, the homeowner must determine heat loss and heat gain requirements. This can

HEATING SYSTEM

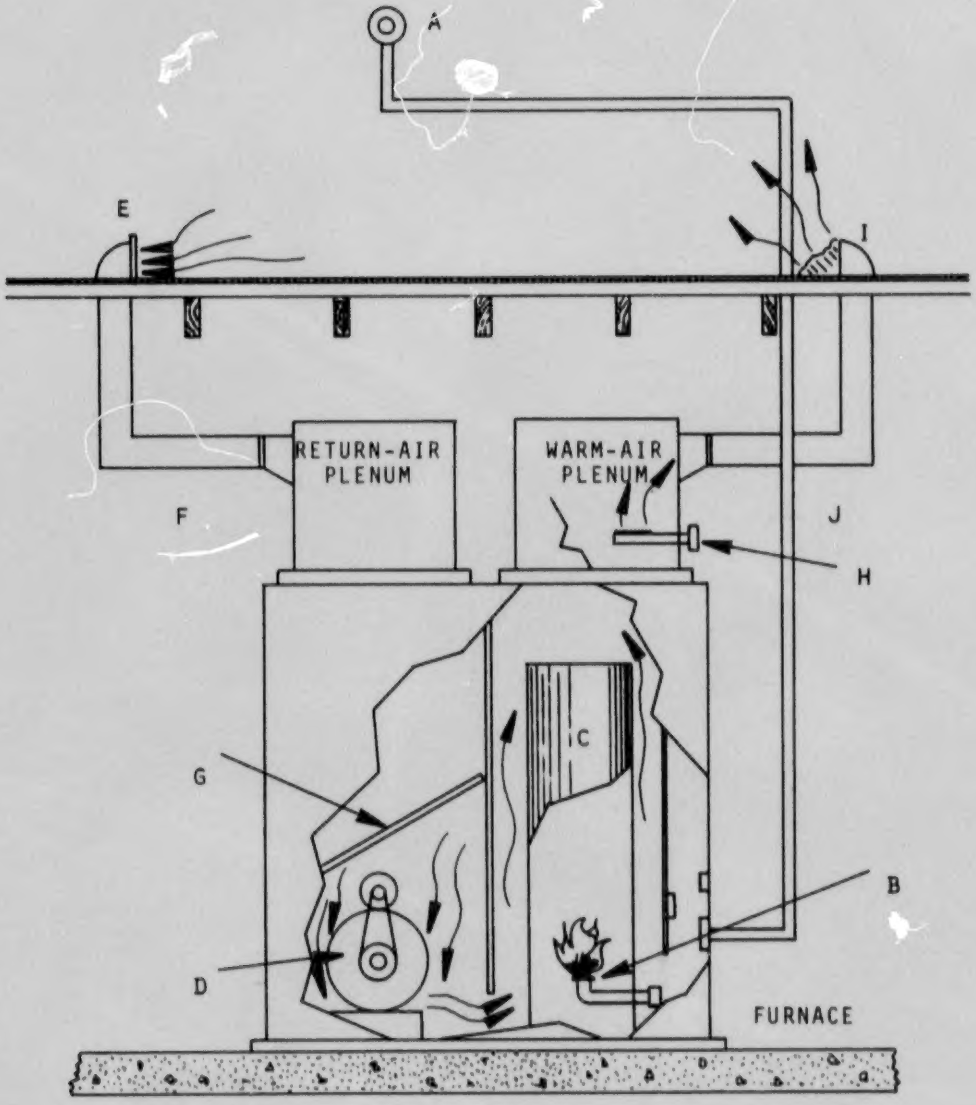

A
E
I
RETURN-AIR PLENUM
WARM-AIR PLENUM
F
J
H
C
G
B
D
FURNACE

FIGURE 2.1

be done quite easily by using the methods of calculating outlined in Module VIII. For this module, however, a simplified method of estimating heating requirements will be discussed.

The most important point to be stressed in sizing and designing a heating system for a particular home is to install equipment that is no larger than required. This concept is relatively new and has gained impetus since the oil embargo of 1973 and the increasing fuel costs. It is not uncommon for buildings built prior to 1974 to have heating systems and circulation fans designed three times larger than the heating requirements. In addition to consuming more energy, oversized equipment results in short periods of operation, poor comfort conditions, and lower seasonal efficiency.

Ideally, output capacity of heating equipment should not be less than the calculated heating load. And, it should not exceed the calculated heat load by more than 15 percent. Cooling equipment output capacity should be no less than five percent below the calculated cooling load, nor more than 12 percent in excess of the calculated cooling load.

Many times, however, it is not possible to obtain equipment within these limitations. If this is the case, then the homeowner should consider the possibility of reducing the heat loss and heat gain of the structure to the point where properly sized equipment can be obtained. As discussed in Module VIII, there are many ways to do this, such as: installing storm windows, increasing the amount of insulation, and reducing the heating load by adding earth berms, etc.

Passive enhancement for heating and cooling is very important. This now only involves the opening and closing of shades in the form of moveable insulation, air flow rates from infiltration, and other passive elements that we have talked about before, including insulation, but there are passive enhancement elements that can be considered within the furnace itself. These include heat exchangers to recover some of the heat that goes up the flue, and more importantly, for the heating cycle is to provide some sort of external source for the combustion air in the furnace. When this external source is provided, the pressure difference or the drop in pressure caused by the thermal chimney effect will cut the infiltration rate. Then a person can control the infiltration rate depending upon the number of people in the house and the current lifestyle activities.

Final selection of heating equipment depends upon the type of system selected, the location of the system in the structure and upon the equipment itself. This will be examined in greater detail in Unit IV of this Module.

Sizing a heating system means selecting a furnace and piping large enough to replace the natural loss of heat from the home. To do this properly means knowing some details about the house and local weather conditions.

Each house must be surveyed individually, because its size and construction is different from any other house. Houses lose heat through exposed ceilings and floors, outer walls, windows and doors. Heat is lost through each of these areas at a different rate because of sizes, types of materials and use of insulation or storm sash.

All factors are reduced to a common measurement of heat--the British Thermal Unit (Btu). This makes it easy to match a proper-size furnace or boiler (outputs expressed in Btu) with the heat loss of any house (also expressed in Btu).

Each geographical location has a design temperature for heating. This is not the lowest temperature recorded, but the lowest temperature reached during 97-1/2% of the time--the only practical approach in designing heating systems. Figure 2.2 gives the design temperature for heating in selected Texas cities.

All the information needed for sizing a furnace or boiler can be entered on the work sheet at Figure 2.3. Much of this information is found just by looking at the house from the outside. This includes: type of house and construction; number of windows and doors; use of storm sash.

Measure the distance around the house (perimeter). This can be paced off, for an approximation, or measured more accurately with a 50-foot steel tape. Inside, check the ceiling height with a folding rule or yardstick. If in doubt about wall and ceiling insulation, look in the attic.

FIGURE 2.2

DESIGN TEMPERATURES FOR HEATING

The following table lists the outdoor winter temperatures in common use in these areas. These are recommended for use as the basis for preparing heating estimates.

STATE AND CITY	DESIGN TEMP.° F
TEXAS	5°
ABILENE	0°
AMARILLO	15°
BROWNSVILLE	30°
CORPUS CHRISTI	25°
DALLAS	10°
DEL RIO	20°
EL PASO	20°
FORT WORTH	10°
GALVESTON	25°
HOUSTON	20°
PALESTINE	10°
PORT ARTHUR	20°
SAN ANTONIO	20°
WACO	10°

Figures 2.4 and 2.5 illustrate how to use the worksheet for estimating heating requirements for a sample house. Study the example before preparing your worksheet.

HEATING ESTIMATE WORK SHEET

TYPE OF HOUSE ______________ STORY

● ATTIC INSULATION ☐ YES ☐ NO
● WALL INSULATION ☐ YES ☐ NO
● STORM SASH ☐ YES ☐ NO

DESIGN TEMPERATURE
OUTSIDE __________ °F
INSIDE __________ °F
DIFFERENCE __________ °F

TYPE OF EXPOSURE		GROSS AREA IN SQUARE FEET	×	MULTIPLIER	=	HEAT LOSS IN BTU'S
EXPOSED WALLS		PERIMETER × CEILING HT. = SQ. FT. ______ × ______ =	×		=	
GLASS	NO. OF WINDOWS NO. OF DOORS TOTAL GLASS	______ × 15 = ______ × 20 = ______	×		=	
COLD CEILING		LENGTH × WIDTH = SQ. FT. ______ × ______ =	×		=	
COLD FLOOR			×		=	

TOTAL HEAT LOSS IN BTU'S NEEDED AT REGISTER OR RADIATOR ➧ ☐

MULTIPLIERS

TYPE OF CONSTRUCTION		**MULTIPLIERS** FOR 70° AT OUTSIDE DESIGN TEMPERATURE						
		−30	−20	−10	0	+10	+20	+30
WALLS	FRAME OR BRICK VENEER STANDARD WALL							
	NO INSULATION	26	24	21	18	15	13	10
	WITH 2" OR MORE INSULATION	13	12	11	9	8	6	5
WINDOWS DOORS	PLAIN SINGLE GLASS	170	150	130	120	105	85	65
	WITH STORM SASH	80	70	60	55	50	40	30
CEILINGS	ATTIC ABOVE—NO INSULATION	32	29	25	22	19	15	12
	ATTIC ABOVE—3½" INSULATION	10	9	8	7	6	5	4
FLOORS	OVER BASEMENT (with furnace)	0	0	0	0	0	0	0
	OVER ENCLOSED CRAWL SPACE—4" INSULATION	5	5	[illegible]	4	3	3	2
	OVER ENCLOSED CRAWL SPACE—NO INSULATION	14	13	11	10	9	7	6
	OVER UNENCLOSED CRAWL SPACE	28	25	22	20	17	14	12
	ON A 4" CONCRETE SLAB	10	9	8	7	6	5	4

OBTAIN ABOVE FORM BY REQUESTING "RESIDENTIAL HEATING ESTIMATE" FORM NC. 29076-1

FIGURE 2.3

X-46

HEATING ESTIMATE WORK SHEET

TYPE OF HOUSE
STORY
● ATTIC INSULATION ☐ YES ☐ NO
● WALL INSULATION ☐ YES ☐ NO
● STORM SASH ☐ YES ☐ NO

DESIGN TEMPERATURE
OUTSIDE °F
INSIDE °F
DIFFERENCE °F

TYPE OF EXPOSURE		GROSS AREA IN SQUARE FEET	×	MULTIPLIER	=	HEAT LOSS IN BTU'S
EXPOSED WALLS		PERIMETER × CEILING HT = SQ FT 148 × 8 = 1184	×		=	
GLASS	NO OF WINDOWS	10 × 15 = 150				
	NO OF DOORS	2 × 20 = 40				
	TOTAL GLASS	190	×	130	=	24,700
COLD CEILING		LENGTH × WIDTH = SQ FT 46 × 28 = 1288	×	8	=	10,304
COLD FLOOR			×	0	=	0

TOTAL HEAT LOSS IN BTU'S NEEDED AT REGISTER OR RADIATOR ➧ 48,028

MULTIPLIERS

TYPE OF CONSTRUCTION		MULTIPLIERS FOR 70° AT OUTSIDE DESIGN TEMPERATURE						
		30	20	10	0	+10	+20	+30
WALLS	FRAME OR BRICK VENEER STANDARD WALL							
	NO INSULATION	26	24	21	18	15	13	10
	WITH 2" OR MORE INSULATION	13	12	11	9	8	6	5
WINDOWS DOORS	PLAIN SINGLE GLASS	170	150	130	120	105	85	65
	WITH STORM SASH	80	70	60	55	50	40	30
CEILINGS	ATTIC ABOVE NO INSULATION	32	29	25	22	19	15	12
	ATTIC ABOVE 3½" INSULATION	10	9	8	7	6	5	4
FLOORS	OVER BASEMENT (with furnace)	0	0	0	0	0	0	0
	OVER ENCLOSED CRAWL SPACE 4" INSULATION	5	5	[illegible]	4	3	3	2
	OVER ENCLOSED CRAWL SPACE NO INSULATION	14	11	11	10	9	7	6
	OVER UNENCLOSED CRAWL SPACE	28	25	22	20	17	14	12
	ON A 4" CONCRETE SLAB	10	9	8	7	6	5	4

HOW TO USE WORK SHEET

There is only one "cold" ceiling – the one immediately below the attic. "Cold" floors are over an open area, on a concrete slab, or over an unexcavated area. Measure the length and width of these surfaces. When you have the measurements and other information filled in, figure the areas by multiplying the length times the width, as indicated on the work sheet.

Total area of exposed walls is the house perimeter (distance in feet around the outside) times ceiling height. For houses with more than one story, total the ceiling heights of all levels except basement, before multiplying by perimeter.

Multiply each of these areas by its indicated construction factor called a "multiplier" . . . to be found in the "MULTIPLIERS" Table on the work sheet. The answers will be in BTUs and will show the heat loss. Equipment is rated in BTUs, so if the total heat loss of the house is known, it is easy to pick a furnace or boiler of the proper size from the *Wards* Catalog.

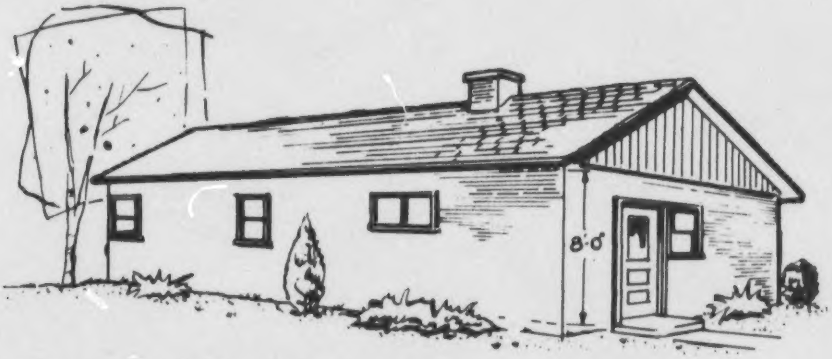
DETERMINING THE HEAT LOSS FOR A SAMPLE HOUSE

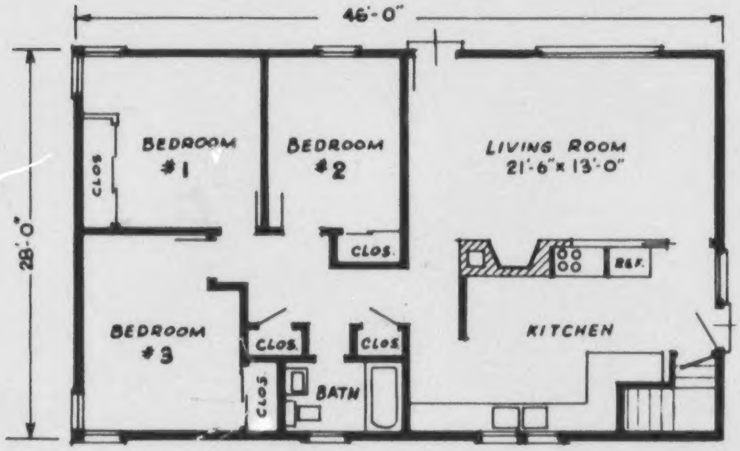
The Type of House

In estimating the heat loss of a sample house *(page 17)*, information and calculations are entered on the Work Sheet as shown above. Here is where they come from . . .

This is a single story house with a full basement. Both the walls and the attic have insulation, but the doors and windows are not protected by storm sash. The design temperature is -10°.

FIGURE 2.4





The Quick, Easy Calculations

WALLS Take the walls first. Walk around the house measuring its perimeter. In this example, it is 46 ft. *plus* 28 ft. *plus* 46 ft. *plus* 28 ft. or a total of 148 ft., which is entered on the form. Now, measure the ceiling height (8 ft). Multiplying these two figures (148 x 8) gives a total wall area of 1184 sq. ft.

Using the -10° column in the multiplier table, a figure of "11" is shown for insulated walls. Multiplying these figures (1184 x 11) gives a wall heat loss of 13,024 BTUs.

GLASS Count the number of windows (10) and multiply by "15." This gives a figure of 150 sq. ft. for windows. Similarly, count the number of doors (2) and multiply by "20" for a square foot figure of 40. Adding windows (150) and doors (40) gives a total glass area of 190. The multiplier for windows and doors without storm sash at -10° is "60". Multiplying these figures (190 x 130) gives the BTU heat loss of 24,700.

CEILING Ceiling area is the length of the house times its width (46 x 28) for a total of 1288 sq. ft. The multiplier for an insulated ceiling at -10° is "8." The heat loss of the ceiling then is (1288 x 8) or 10,304 BTUs.

FLOOR As the house has a full basement in which the furnace will be, the multiplier is "O". Therefore, the area of the floor need not be considered (since O x anything is still "O") . . . and the heat loss through the floor is nothing ("O").

TOTAL HEAT LOSS This is just the sum of the individual heat losses (13,024 plus 24,700 plus 10,304 plus 0) which is a total of 48,028 BTUs. This indicates the total amount of heat (in BTUs) that will be needed in the house. To obtain this amount of heat requires a furnace with an output rating (at the registers) of 48,028 BTUs, or more.

FIGURE 2.5

C. FUEL COSTS

Once the heat load of a home has been established and the size of the heating system has been designed, the type of heating system to install must be determined. This question is predicted on the type of fuel available in a particular area and the fuel costs for operation.

All energy sources are sold in units, such as the gallon, the cubic foot, or the kilowatt-hour. The cost per unit doesn't tell what it actually costs to heat the house. To figure this one must know how much heat energy one can get from one unit of each energy source. That is, how many Btu are produced from each unit bought. This information is given in Figure 2.6.

Check with local fuel suppliers to find out the price of one unit of each type of fuel. Estimate your approximate fuel consumption for a typical winter heating month; then ask the fuel supplier what the cost would be so you can figure the average cost per unit.

FIGURE 2.6

COMMON FUELS AND THEIR HEAT ENERGY PER UNIT

FUEL	UNIT	BTU PER UNIT
natural gas	cubic foot	1,000
	therm (100 cu ft)	100,000
propane	gallon	90,000
butane	gallon	130,000
No. 1 fuel oil	gallon	136,000
No. 2 fuel oil	gallon	140,000
electricity	kilowatt-hour	3,413

Note: Propane and butane are gases that become liquids when pressurized and are sold by the gallon. Liquid petroleum gas (LPG) is a name commonly applied to both propane and butane, or even a blend of the two. In general, propane is used in the north, while butane is used in the south.

Fuel costs can then be estimated by using the following formula:

$$C = \frac{F \times E}{P}$$

Where

C = cost per Btu of heat energy, in Btu per dollar

F = Btu value of fuel

E = efficiency of your heating system, in percent

P = price of fuel, in cents per unit

D. HEATING SYSTEM EFFICIENCY

There are several types of fuel used in heating systems. Figure 2.7 shows the efficiencies of several of the most popular heat sources. The efficiency of a heating system is based on the amount of heat energy that actually goes into the living area, which is compared to the total amount of heat generated inside the furnace. Not all the heat generated goes into the living area-some of it goes up the flue and some of it is lost in the ductwork as the heat passes through unheated parts of the house. The advantage to electric heating is that no flue is needed, since there are no exhaust gases due to combustion. Electric baseboard heaters, for example, have an efficiency approaching 100% because practically all of the heat generated inside them is delivered to the area being heated.

To illustrate how this formula is used, let's consider a house with an electric furnace having an efficiency of 90%, and located in a city where the utility company charges 2.5 cents per kilowatt-hour. Putting these numbers into the formula, we get:

$$C = \frac{3413 \times 90}{2.5} = 122{,}868 \text{ Btu per dollar}$$

As another example, let's consider a house with an oil furnace having an 80% efficiency and located in an area where No.2 fuel oil costs 40 cents per gallon. In this case, the formula tells us that the cost is:

$$C = \frac{140{,}000 \times 80}{40} = 280{,}000 \text{ Btu per dollar}$$

The fuel costs in these two examples do not tell the whole story. You would also have to weigh the cost of installing the particular heating system and any additional insulation you might add to your house. Then there is the question of what fuels are available in your area. So you can see there are actually many factors to consider.

The cost of the heat energy can give you a pretty good idea as to what fuels and heating systems would be more economical in your area. Just the number of Btu per dollar can tell you a lot. You could also estimate the heating bill by determining the heat load of a particular house for the average temperature difference during the winter heating season. Since the heat load is in Btu per hour, you would have to include the number of hours in each billing period

FIGURE 2.7

HEATING SYSTEM EFFICIENCY

HEAT SOURCE	EFFICIENCY
wood furnace or stove	30-50%
coal furnace	30-60%
natural gas furnace	75-80%
propane furnace	75-80%
butane furnace	75-80%
oil furnace	75-80%
electric furnace	90-100%
electric baseboard	95-100%

1. FUEL FURNACE

Fuel furnaces must have flues to expel the combustion fumes, and these flues unfortunately carry away large amounts of heat energy. Woodburning units have the lowest efficiency rating--as much as 70% of the heat produced from the burning wood is wasted as it goes up the flue. Coal furnaces are almost as inefficient.

or over the entire heating season. For instance, if the home with the electric furnace happened to have an average (not maximum) heat load of 25,000 Btu over a six-month heating season (about 4400 hours), the total heating cost would be:

$$\frac{25,000 \text{ X } 4400}{122,868} = \$895$$

A rough estimate of the average heat load during a typical heating season can be obtained from the nameplate on your furnace. In most houses, the average heat load over a six-month period works out to between a third to a half of the Btu rating of the furnace. A furnace with a 100,000 Btu rating would then indicate that the house had an average heat load of about 30,000 to 50,000 Btu per hour. Better estimates of your fuel costs can usually be furnished by local fuel suppliers. Refer to Module IV for further discussion on utility rates and fuel bills.

Therefore, the flue damper is directly involved with the efficiency of the heating system. Ideally, a fuel-burning furnace needs only enough air to assure that all of the fuel is cleanly burnt. Not enough air will prevent the fuel from burning completely, producing soot and dangerous carbon-monoxide fumes. Too much air, on the other hand, only cools the combustion temperatures and carries more heat up the flue. Hand-fed heating systems are therefore very inefficient because the damper setting must also be controlled by hand, reducing the efficiency to about 30 percent. If an automatic feeder and automatic damper are added, however, the efficiency of these units can be increased to about 50 percent.

Natural gas, propane, butane, and oil furnaces have efficiency ratings of about 80 percent. If the gross input Btu to a furnace is listed as 100,000 Btu one would expect the net figure given as 80,000 Btu. But in practice, one could achieve a slightly higher net heating capacity with a finely tuned furnace--and a much lower output with a poorly tuned one.

The higher efficiencies of gas and oil furnaces are due primarily to their construction. The amount of fuel fed into the furnace is carefully and automatically controlled when properly adjusted. The heat exchanger in such furnaces is also constructed to extract the maximum amount of heat energy from the hot gases produced as the fuel burns. Finally, the air flow through the combustion chamber is regulated by dampers to insure good combustion of the fuel. However, if the furnace is not properly adjusted and cleaned for maximum heat transfer, one cannot expect to obtain good heating efficiency.

If the air flow to the burner of a gas or oil furnace is not correct, the efficiency can drop to less than 50 percent. The flame of a gas furnace should be a bright blue color. If it is yellowish in color, the air flow could be adjusted too low or it may be that the gas pressure is too high; if the flame is erratic or jumps off the burner, the air flow may be adjusted too high or the gas pressure may be incorrect. When the adjustments are not correct on an oil-burning furnace, the flame smokes, causing problems with smut build-up in the flue or chimney.

Air flow through the heat exchanger in a furnace is also quite important. If the heating ducts or cold air returns are too small, the furnace will not deliver its rated heat capacity. A safety thermostat on the heat duct leaving the furnace prevents the air temperature from exceeding safe levels. If the temperature rises too high, the high-temperature-limit thermostat turns off the burners until the air temperature drops to a safe level again. If the burners on the furnace turn ON and OFF even though the room thermostat is demanding more heat, that means the limit thermostat is operating, and this in turn indicates that there is probably not enough air flow through the ductwork.

Every forced-air furnace has air filters in the cold air intake to prevent dust particles from collecting in the furnace and ductwork. If dust collects in the burner box, heat conduction to the air is not only decreased, but a fire hazard is also created. If one smells scorched air from the heat registers, it is likely some dust has gotten into the burner box. A clean air filter will assure maximum air flow through the furnace.

The actual efficiency of a heating system will depend on several factors:

1. Properly adjusted burners.
2. Clean nozzles and jets.
3. Correct fuel pressure at the nozzles and jets.
4. Clean fuel filters.
5. Clean air filters
6. Properly adjusted nozzle and jet openings.
7. Correctly sized supply and return air ducts.
8. Well-lubricated furnace blower.
9. Automatic (rather than manual) furnace operation.

If any of these factors is out of line, the efficiency of the system will drop, wasting both fuel and money.

2. ELECTRIC FURNACES

Electric furnaces resemble fuel furnaces, but differ because no combustion takes place. As a result, there are no burner adjustments to make and no flue pipe to waste heat. An electric furnace, therefore, requires little maintenance to keep the unit operating at maximum efficiency of 90-100%.

Electric furnaces, however, have much in common with fuel furnaces when it comes to the ductwork and blower that circulates heated air throughout the house. For this reason, most of what has been said about the size of the ducts, clean air filters, and routine maintenance also applies to electric furnaces.

Because of the relatively high cost of electricity as compared to other fuels, the efficiency of an electric furnace system is of paramount concern. Heat losses cannot be tolerated, and every step must be taken to thoroughly insulate and seal the home. Most of the heat loss occurs in the duct system, so it is important to properly insulate and seal ducts passing through garage areas and open crawl spaces. Most all-electric homes are built with considerably more insulation than other homes to offset the higher cost of electricity, so adding more insulation to the house is usually a good idea.

3. HEAT PUMPS

A heat pump is the most efficient type of mechanical heating system. A heat pump does not have to burn fuel to produce heat, and it does not have to waste electrical energy by running it through a resistive wire element to produce heat. The heat pump only requires enough electricity to run a compressor motor, which takes the heat out of the air on the outside of the house and deposits this heat inside the house.

The heat pump is actually a kind of refrigeration or air- conditioning system that can work in reverse. In summer, the heat pump cools the house in the usual manner, removing heat from within the house and depositing it outside. In winter, the heat pump works in reverse, removing heat from the outside and depositing it inside.

The efficiency of a heat pump is measured in terms of how much easier it is to pump heat energy than to generate it by conventional means. When used to heat a house, the efficiency of a heat pump depends primarily on how cold it is inside. As the temperature drops, efficiency also drops. If it gets too cold outside, the heat pump automatically switches an electric heating element to ON, when it becomes easier and more economical to generate heat energy that way. Normally, though, as long as the outside temperature is above about 20°F, the heat pump can heat the house more cheaply than an electric furnace. As the outside temperature approaches the inside room temperature, the efficiency continues to climb dramatically.

Taken on a year-around basis, a heat pump can usually heat a house for one-third to one-half the cost of conventional electric heat. In a northern city like Cleveland, Ohio. For example, the annual heating cost for a heat pump is about 50% of that for an ordinary electric furnace, making the heat pump cost-competitive with natural gas in that area. In southern states, operating efficiency is much higher because outside temperatures are higher.

Heat pumps cost substantially more to purchase and install than conventional heating systems with central cooling. Manufacturers and representives claim, however, that the heat pump can greatly reduce the heating bill, so it would not take long to make up the differences in the original purchase prices. Keep in mind, however, that location has a lot to do with the cost savings. As long as the winter temperature in an area stays high enough, the heat pump will save quite a bit on a heating bill. As temperatures drop, so do the savings. At lower temperatures, the electric resistance heat is turned on automatically to assist the heat pump.

4. ELECTRIC BASEBOARD HEATERS

An electric baseboard heater may operate at nearly 100 percent efficiency since there are no fans and no duct system to waste heat. This assumes, however, that the unit is wired properly and is perfectly clean. The efficiency of a baseboard heater will be reduced if the heating element gets dirty, thus reducing the transfer of heat that should go into the room.

Baseboard heaters should be cleaned with a vacuum cleaner at least once a year to avoid this problem.

E. MAINTENANCE

1. FILTERS

All central heating systems have filters. These filters all get dirty--that's their job! They take the dust and lint particles out of the circulating air so dirt does not clog the working parts of the furnace. The air filter is usually located in the return air duct where the cool air enters the furnace to be heated. As the filter removes the dirt from the air, the filter itself becomes clogged and restricts the air flow, cutting down on both the efficiency and capacity of the furnace. Filters should be checked every month and either cleaned or replaced.

2. FANS

The fan most used in heating systems is the squirrel cage fan. This fan circulates the air through the furnace and duct system. Over a period of time--even with regular filter replacements--the blades and motor of the fan will become covered with dirt, reducing air flow in the furnace. Clean the fan blades with a brush and soapy water. Be careful not to move any of the balance weights from the fan blades.

3. ADJUSTING LIQUID PETROLEUM AND NATURAL GAS FURNACES

A gas furnace may burn natural gas (methane), propane gas, or butane gas. Natural gas is delivered to the house through underground gas lines, while liquid petroleum gas (LPG) is stored near the house in supply tanks with direct feed lines to the furnace.

The gas flow to the furnace is regulated by a gas valve in the line, which meters the amount of gas entering the burners within the heat exchanger. Air is mixed with the gas there and is ignited to produce heat.

To get the highest amount of heat energy from the furnace, the gas and air mixture must be just right. To accomplish this feat, a series of regulators control the flow of gas to each burner, and each burner has an adjustment mechanism to control the air flow.

a. Gas Valves Manifold

The gas valve controls the flow of gas into the manifold, a pipe which connects the gas valve and the burners. Gas flows from the valve into the manifold, which distributes the gas to the burners. When the furnace is not heating and the thermostat is not calling for heat, the gas valve is closed. When the thermostat calls for heat, an electrical solenoid in the gas valve opens, permitting gas to flow through the valve into the manifold.

If the pilot light goes out, the gas valve will close to safely prevent gas from escaping into the furnace room and house. The gas valve closes when the pilot light goes out because the thermocouple, a temperaturesensing device, is no longer heated by the pilot light.

If a leak develops in the gas valve, gas can enter the furnace and room even when the pilot light is off. This not only wastes gas and money, but it can also be very dangerous, leading to fire or explosion. Therefore, check for gas valve leaks.

b. Adjusting the Air Mixture

The flame in the burner should be bright blue in color close to the burner. If the flame is not burning correctly, the first place to check is the air adjustment. When there is not enough air, the flame will usually have a yellowish color. This means the flame is not burning hotly, so it will take more gas than it should to heat an area. Too much air causes the flame to burn with a pale blue or white color.

c. Cleaning the Burners

Burners must be kept clean because if the air flow is out of adjustment on the burners for a long time, soot may collect around the burners openings. The flame may even burn inside the burner body or at the gas jet opening and build up carbon and soot inside the burner. Sometimes dust and lint in the air will also collect in the throat of the burner and partially block the air flow. In damp locations, the burner can become spotted with rust.

Clean the burners with compressed air to remove dirt, lint, and loose soot. If the burners are oily, wipe them carefully with a cloth, but be careful not to bend or break the burners. As a last resort, if there are some really tough buildups of soot, use a cleaning solvent to dissolve the dirt.

d. Adjusting the Gas Pressure

The gas pressure also affects the mixture of the gas and air going to the burners. If one has tried adjusting the air flow to the burners, has cleaned the burners, is sure that all gas connections are tight, and still has a flame that does not burn properly at the burners, the gas pressure may not be correct. A sure indication of pressure problems is a flame that is too large or too small.

To measure gas pressure, a special gauge is used to indicate the pressure in inches of water, indicated by the height of the water column in a glass tube. Gas companies and repair services have them. Do not attempt to adjust the gas pressure without using the proper set of gauges.

e. Adjusting the Pilot Light

The pilot light in most gas furnaces burns continuously, although a form of electric ignition is used on some newer furnaces. Before adjusting the pilot light, it's a good idea to inspect it to insure that it is reasonably clean. A dirty or clogged pilot is often responsible for the pilot light going out, and a pilot light that is too small often causes noisy ignition of the burners. To clean the pilot light, remove it from the burner assembly.

Some forms of electric ignition use a hot wire to ignite the pilot, which then heats the thermocouple, which in turn allows the burners to turn on. Oil furnaces generally use arc igniters to light the fuel. Electric ignition systems can save fuel, but problems can also develop with these. In hot-wire systems, for example, the wire element can fail, but this is easily replaced with a new unit. An advantage of such systems is that the pilot and thermocouple parts are not on most of the time, so they do not have to be cleaned or adjusted as often.

4. ELECTRIC FURNACES

An electric furnace will usually operate properly and at maximum efficiency for many years without adjustment. Since there is no fuel combustion taking place, there will not be problems with carbon and soot buildup. Thus, any dirt that could decrease efficiency in an electric furnace must come from the air circulated inside the house. Keeping the air filters clean is therefore an important part of maintaining an electric furnace. Since there is no combustion, the electric furnace also has no flue to waste heat energy. As a result, almost all of the heat produced by the furnace elements ends up in the house.

Heat is generated in an electric furnace by passing electric current through resistance wires. When these heating elements raise the temperature of the air enough in the heat chamber, the fan starts and circulates the warmed air throughout the house. These electric heating elements draw a great amount of electrical power, so it is essential that adequately sized wires are run to the furnace to supply all the current needed. Normally, local building codes insure that the proper size of wiring is used, since the current passing through these wires also produces heat, which is wasted.

a. Maintaining the Fan

The fan controls on an electric furnace are usually preset and cannot be adjusted. The switches that turn the fan ON and OFF, for example, are sealed units mounted in the heat chamber. The limit switch is usually a metal fuse (rather than a circuit breaker), and melts when the furnace elements get too hot. Consequently, if the fan does not come on for some reason, the fuse will open, requiring that it be replaced after the fan is repaired.

About all one can do in maintaining an electric furnace is to keep the fan blades, fan motor, and filters clean. If a regular maintenance schedule is kept, few problems will be encountered.

b. Checking the Thermostat

An electric furnace usually has a special two-stage thermostat that prevents waste of energy. For example, consider an electric furnace with four heating elements. When the thermostat calls for heat, the first two elements come on immediately. The second two elements will not turn on unless the thermostat senses a big drop in temperature or unless the last two elements do not heat the house fast enough. This technique gives some energy savings to the homeowner because the second two elements are not used until they are needed.

Sometimes an outside thermostat is also attached to the two-stage thermostat inside the house. In this system, if the temperature outside remains above a preset temperature (usually about 35°F), the second stage of the thermostat cannot come on.

F. HUMIDIFIERS

Relative humidity is the percentage of moisture in the air relative to the amount of moisture the air could hold at that temperature. People generally feel uncomfortable when there is too much or too little moisture in the air. During the summer, for example, a relative humidity of more than 70 percent makes the air feel damp, close, and sultry. During the winter, a relative humidity of less than 30 percent makes the air feel dry, irritates the nose and throat, and encourages the buildup of static electricity in rugs, upholstery, and clothing. Dry air also makes the air feel cooler because it speeds up the evaporation of moisture from the body.

Proper humidification is very important with respect to maintaining a comfort index at a comfort level within the structure. If one has proper humidity the comfort temperature can be dropped from 70 to the mid-60's without any noticeable change in perceived comfort. If the air is dry then the room will feel cold in the mid-sixties plus the simple fact that static electricity is highly uncomfortable in any social interaction.

During the heating season, it is difficult to maintain a suitable level of humidity because the cooler air outside the home contains very little moisture. For example, if the temperature is 50°F outside with 100 percent relative humidity, the humidity will drop to less than 20 percent by the time the air has been heated to 70°F. For outside temperatures below freezing, the air contains practically no moisture. For this reason, the relative humidity in your home will be very low during the coldest winter months.

Many schemes have been tried for increasing the humidity level in a home during the winter. You can boil pans of water on the stove, hang wet clothes to dry in the basement, drape wet towels over radiators, set water-filled pans on the floor, etc. But if not inefficient, these methods are messy to say the least. Most modern furnace humidifiers require a minimum of maintenance, and a selection of models is available in a wide price range.

All humidifiers should be inspected once a year before the heating season begins. Evaporator-type humidifiers should also be inspected a couple of times during the winter to be sure that accumulations of lime and minerals from the evaporating water do not clog the water-inlet valve or the fins, belts, and bristles.

As water is evaporated from the humidifier, lime and mineral deposits are left behind. These collect on the valve seat, so they must be removed periodically. If they are not, the valve may not close, causing the water basin to overflow.

To clean the humidifier, first remove it from the bottom of the duct. You can drain the water from the basin of the humidifier through the drain hole in the bottom. Scrape all the mineral deposits from the float, the valve, and the valve seat. Remove the mineral deposits from any other part of the humidifier and water lines.

1. OPERATION AND MAINTENANCE

-Read the owner's manual.

-Place the unit near a room partition and allow 6 inches behind it for circulation.

-Avoid small rooms, heat sources, and corners. The bottom of a stairway is a good location.

-For the first few days, adjust at high settings to moisten air, walls, and furniture. Turn down as dampness develops.

-Set humidistat at a level for personal comfort.

-Disconnect the unit when filling or cleaning the water reservoir. Be sure the area and unit are dry before reconnecting the cord.

-Do not pour hot water in the reservoir or overfill it.

-Dust the grilles every week with a soft brush.

-Every few weeks, empty the reservior and scrub the inside with a sponge and a mild detergent to prevent mold, mildew, and bacteria.

-Clean the filter pad monthly.

2. FUEL SAVINGS

For years, it has been common knowledge that people feel warmer when the humidity in a room is higher. Generally, you can figure that each 10 percent increase in relative humidity enables you to turn down the room thermostat by about one degree. This would seem to indicate a substantial fuel savings can be obtained by using a humidifier, but one has to be careful about such claims. The savings are not as great as some manufacturers would have their customers believe.

You will remember that when water evaporates, it absorbs heat energy. Your furnace has to supply this heat energy when you use a humidifier--and it takes over 8,000 Btu to evaporate just one gallon of water. Fortunately, however, the average size home needs less than one gallon of water evaporated into the air to bring the relative humidity from 0 up to 50 percent. Since there are many other sources or water vapor in your home, your furnace humidifier does not have to supply very much water each day to maintain the humidity at a comfortable level. Of course, this depends upon how much infiltration air enters your home, pushing out the moist air. The more tightly sealed your home is, the more moisture it will be able to retain, and the less water vapor the humidifier will have to add to the air to replace what was lost.

As an example of cost, let's use the home in Chapter 6 that had an average heat load of 25,000 Btu per hour over a six-month heating seasons. During the average 24-hour day, this furnace would consume 600,000 Btu of heat energy, and assuming that the humidifier used up a whole gallon of water in that time, 8,000 Btu of heat energy would be needed to evaporate the water. Now, if having a 50 percent relative humidity inside the house would permit you to turn down the thermostat just two degrees, the furnace would consume 30,000 Btu less energy on a day that the outside temperature was 40 degrees less than the inside. Clearly, the 8,000 Btu expended in evaporating the gallon of water saved you quite a bit of fuel energy. In general, the energy savings will pay for the furnace humidifier in about two to five years, depending on how much moisture you have to add to the air in your home and the cost of the unit.

G. SPACE HEATERS

For a small house or apartment in areas with mild winters, a heating unit such as a wood stove, coal stove, fireplace, gas heater, oil heater, propane heater, or electric space heater can be more economical than a central furnace.

When choosing a space heater, keep safety and energy use in mind. Electric heaters should be considered last because they are heavy users of energy. Non- electric heaters should be properly vented. If venting is inadequate or the adjustments faulty, deadly quantities of carbon monoxide may be produced. Many states prohibit unvented units because of this hazard.

A space heater should have a guard around the flames or coils to protect children, pets, and clothing from the heat source. Allow adequate clearance on all sides of the unit.

To keep the heater in good working order, inspect it regularly for needed adjustments, dust or dirt, cracks, faulty legs, and hinges. Keep the electrical wiring in good condition.

For Safe Operation of Space Heaters:

-Keep a window partially open if an unvented unit must be used. Fresh air will prevent the accumulation of gas fumes.

-Use only the fuel the heater is designed for. Do not convert to another fuel without consulting an expert.

-Keep children away from space heaters and stoves.

-Be certain the fire has proper ventilation to maintain a constant rate of burning that gives moderate heat--not too hot or too cool.

-Always keep a screen around any heater that has open flames.

-Keep the damper open while fuel is burning. This will provide for efficient burning and will prevent accumulation of explosive gases.

-Learn how to light a gas heater properly. If someone smells gas, turn off all controls and open a window. Don't allow gas to accumulate. If a heater fails to light on the first try, allow sufficient time for the gas to dissipate before trying again.

-Never keep flammable liquids around heaters. Vapors can be ignited by the open flames.

-Use heavy-duty cords for electric heaters. Have an electrician check the wiring if a heater uses higher than usual wattage.

-Never place an electric heater near a bathtub, shower, or sink. Don't touch one when wet.

-Place a metal sheet under the unit to protect the floor from live coals, burning, or overheating.

The fireplace is used today primarily as an enjoyable addition to a home. Watching the flames can bring peace to the heart and soothe the soul. Even more importantly, however, the fireplace can be used to supplement central heating. On cool days, the fireplace might provide the necessary heat to take away the chill.

The most energy-efficient fireplace will have warm air vents through which hot air can be spread around the room or through ducts to other rooms. A modified fireplace with a fan can also help circulate hot air effectively.

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To obtain maximum efficiency from a fireplace, be sure the chimney is working as it should. If the chimney is too low, the draft will not be strong enough to pull out the smoke. Keep the chimney clear of ashes and be sure the flue is operating properly.

H. ENERGY-SAVING TIPS IN HEATING

The U.S. Department of Energy has outlined tips for saving energy in heating. This list serves as a summary of conservation measures available to the homeowner when considering heating the home.

Heating and cooling homes account for most residential energy costs. Don't waste any of that precious conditioned air (whether you pay for it yourself, or you pay your landlord for it).

During both heating and cooling seasons. . .

-Close off unoccupied rooms and shut the heat or air conditioning vents; or turn off room air conditioners. (This does not apply if you have a heat pump system. Leave it alone; closing vents could harm a heat pump.)

-Use Kitchen, bath, and other ventilating fans sparingly. In just one hour these fans can blow away a houseful of warmed or cooled air. Turn them off just as soon as they have done their job.

-Keep the fireplace damper closed unless a fire is burning. An open damper in a 48inch square fireplace can let up to 8 percent of the heat out the chimney.

Heating Energy Savers

Don't turn the heat on until necessary. On cool evenings, use the fireplace instead, and add an extra blanket at night.

With heating equipment. . .

-If using an electric furnace heating, consider a heat pump system. The heat pump uses thermal energy from outside air for both heating and cooling. Costs for these pumps run from about $2,000 for a wholehouse unit to about $425 for room size, but they can cut your use of electricity for heating by 30 to 40 percent and also can provide some savings in cooling costs.

-If planning to buy a new gas heating system, ask the gas utility or public service commission about the savings potential of electronic ignition. Ask also about possibilities for retrofitting any older system in use.

-Consider the advantage of a clock thermostat for the heating system. The clock thermostat will automatically turn the heat down at a regular hour before you retire and turn it up again before you wake. While it is easy to turn the thermostat back at night and up again in the morning, the convenience of a clock thermostat may be worth the $70 to $90 cost.

-Consider buying a properly sized furnace that incorporates an automatic flue damper. This device reduces the loss of heat when the furnace is off. (Contact the gas utility or oil supplier for guidance.)

-Don't use the fireplace for supplemental heating when the furnace is on unless taking one of the measures suggested below to lessen the loss of heated air from the house.

The warmth from a fire on the hearth generally doesn't radiate through the house. The heat gain is confined to the room with the fireplace, and when the furnace is also on, a considerable amount of heated air from the rest of the house is drawn into the fireplace and goes wastefully up the chimney. Then, the temperature in other rooms of the house goes down, and the furnace uses more fuel to raise it to the level controlled by the thermostat. Thus, more rather than less fuel is needed when both the furnace and fireplace are in use.

Lessen heat loss when using the fireplace when the furnace is on by:

-Lowering the thermostat setting to 50 to 55 degrees. Some warmed air will still be lost, but the furnace won't have to use as much fuel to heat the rest of the house to these temperatures as it would to raise the heat to 65 degrees.

-Closing all doors and warm air ducts entering the room with the fireplace and opening a window near the fireplace about 1/2 to 1 inch. Air needed by the fire will be provided through the open window and the amount of heated air drawn from the rest of the house will be reduced.

-If using a simple, open masonry fireplace, consider installing a glass screen. This will cut down on the loss of warmed air through the flue.

When using the heat . . .

-Lower the thermostat to 65 degrees during the day and 55 degrees at night. This can save about 3 percent on fuel costs for every degree the average temperature in the home. In addition, about 1 percent on the heating bill can be saved for every degree dialed down only at night.

-Keep windows near the thermostat tightly closed, otherwise the furnace will be working after the rest of the room has reached a comfortable temperature.

-Have an oil furnace serviced at least once a year, preferably each summer to take advantage of off-season rates. This simple precaution could save 10 percent in fuel consumption.

-Clean or replace the filter in a forced-air heating system each month.

-Check the duct work for air leaks about once a year if you have a forced-air heating system. To do this, feel around the duct joints for escaping air when the fan is on.

-Relatively small leaks can be repaired simply by covering holes or cracks with duct tape. More stubborn problems may require caulking as well as taping. Almost 9 percent in heating fuel costs could be saved this way.

-If using oil heat, check to see if the firing rate is correct. Chances are it isn't. A recent survey found that 97 percent of the furnaces checked were overfired.

-If the oil furnace doesn't run almost constantly on a very cold day, call a service person.

-Don't let cold air seep in through the attic access door. Check the door to make sure it is well insulated and weatherstripped, otherwise fuel will be wasted heating that cool air.

-Dust or vacuum radiator surfaces frequently. Dust and grime impede the flow of heat. If the radiators need painting, use flat paint, preferably black (it radiates heat better than glossy).

-Keep draperies and shades open in sunny windows; close at night.

-For comfort in cooler indoor temperatures, use the best insulation of all--warm clothing.

The human body gives off heat--about 390 Btu per hour for a man, 330 for a woman. Dressing wisely can help one retain natural heat.

-Wear closely woven fabrics. They add at least a half a degree in warmth.

-For women--slacks are at least a degree warmer than skirts.

-For men and women--a light long-sleeved sweater equals almost 2 degrees in added warmth; a heavy long-sleeved sweater adds about 3.7 degrees; and two lightweight sweaters add about 5 degrees in warmth because the air between them serves as insulation to keep in more body heat.

If every household in the United States lowered its averge heating temperatures 6 degrees over a 24-hour period, more than 570,000 barrels of oil per day (or more than 3.5 percent of current oil imports) could be saved.

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

UNIT III

COOLING SYSTEMS

UNIT OBJECTIVES

1. Identify the components of a typical air conditioner.
2. Distinguish between the uses of room air conditioners and central air conditioning systems.
3. Calculate and size an air conditioner for a particular cooling need.
4. Discuss maintenance and use tips for efficient air conditioning performance.
5. Discuss the role of dehumidifiers in summer cooling.

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

UNIT III

COOLING SYSTEMS

LECTURE	ACTIVITIES

INTRODUCTION:

There are several types of air-conditioning systems for cooling the home during the hot summer months: a wide range of window air conditioners, central air conditioners, or heat pumps. All of these systems work in essentially the same way, and all require similar maintenance to keep them working at top efficiency.

Most homes built today have the capability of easy conversion to central air conditioning, if they do not already have it. Homes built with heat pumps to provide heat during the winter also use the same unit to provide cooling during the summer. Most room air conditioners are used today where only one or two rooms are to be cooled, or where central air conditioning is impractical or unnecessary. Thus, the type of air conditioning one has or wants depends on the cooling needs and the cost of installing a particular system.

A. AIR CONDITIONER COMPONENTS

An air conditioner cools air much as a refrigerator cools the air inside it. The principal difference is that an air conditioner is designed to have the cooled air blown through the cooling coil and out (through whatever distribution system is used) into the house. . . then back (through return-air system) to the coil for recooling.

While cooling the air, the coil condenses the moisture carried by the air, and the resulting water runs off through a water line to leave the air less humid.

Whatever type the air conditioner, it will have the functional parts illustrated in Figure 3.1. A blower-coil or a self-contained unit has, in addition, an electric-motor-driven blower to circulate house air through the cooling coil. The refrigerant, which circulates from cooling coil to compressor to condenser, and back to the coil, is a volatile liquid (such as Freon) which changes from gas to liquid and back to gas as the pressure and temperature to which it is subjected changes.

Gas (at low pressure) moves from the coil to the compressor, where it is compressed and forced on to the condenser in the form of a hot gas or vapor. Here the hot gas is cooled (by outside air) and becomes a liquid. This liquid, still under pressure, travels to the cooling coil where it is allowed to expand (pressure is relieved) into a gas again. While expanding it absorbs heat to keep the coil relatively cold...and thereby cools the house air blown through this coil. A thermostat can be used to control compressor operation and/or blower operation to maintain desired house air cooling.

B. TYPE OF AIR CONDITIONERS

1. Room Air Conditioners

A room air conditioner can be installed either in a window or through a wall. There are many different models, designs, and styles available--ranging in size from small units able to cool just one room, to large units used to cool three or four rooms. Large units are often mounted through the wall and become permanent installations.

Thermostat control provides one of the easiest ways of maintaining the house in a comfort system and reducing the amount of energy necessary. Thermostats can be single, or can be multiple with some sort of switching option. In thermostat control, the basic thing is to look at your schedule: when you will be in the home and out of the home, and adjust the desired base-line temperatures accordingly. Most people do not think to turn thermostats down when they leave, or to turn thermostats down at night. But, by this choice of options using some sort of programmed clock thermostat which can either be day- or nighttime or which can be a seven-days thermostat, an appreciable savings of maybe 10-15-20% can be made in the overall fuel cost (by just turning the furnace down at night, shall we say, to 60-64°F and may be maintaining it in the day at about 68-70°F). Obviously, when no one is to be at home for 6-8 hours, the furnace can be turned to the lowest setting.

AIR CONDITIONING SYSTEM

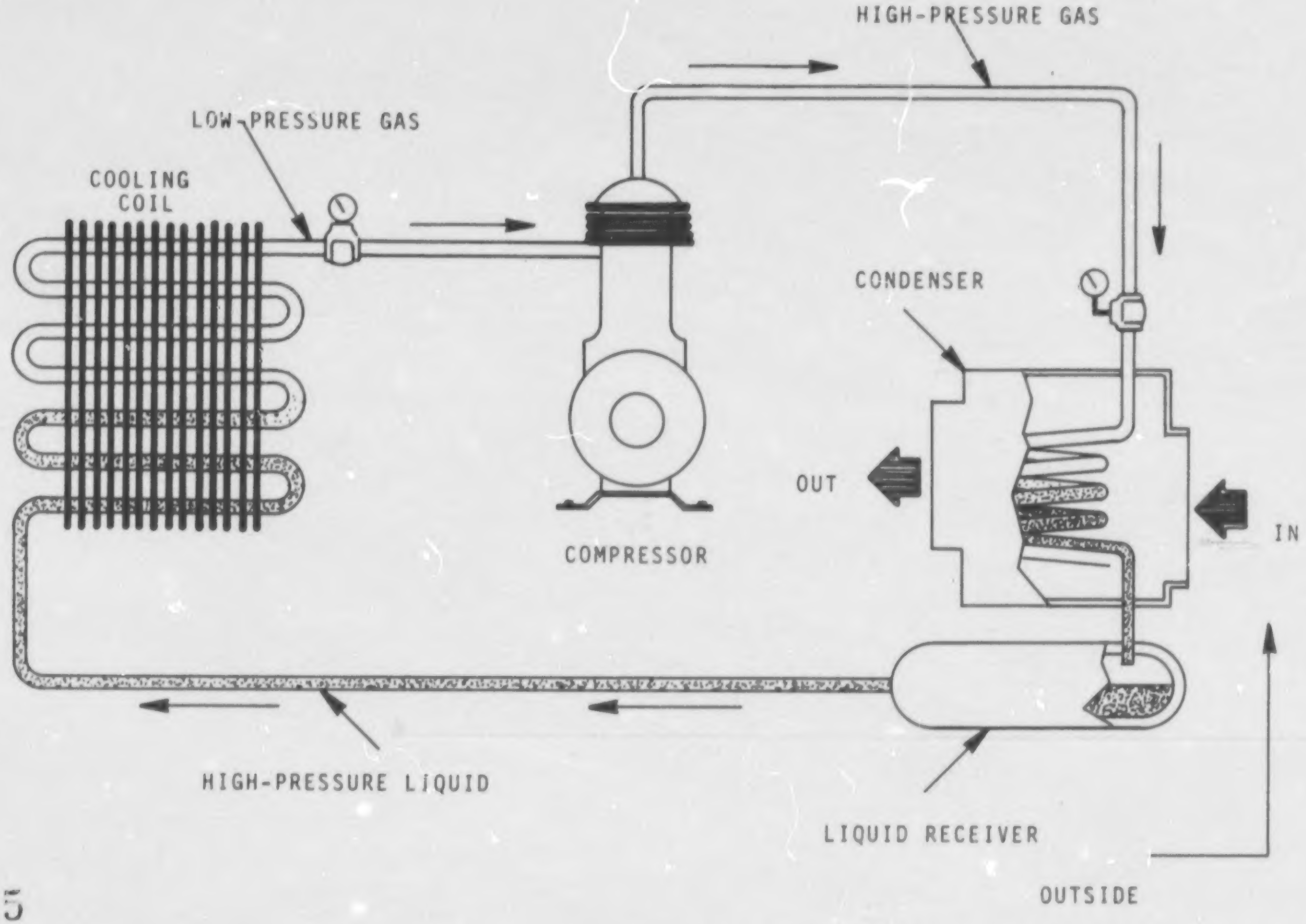

HIGH-PRESSURE GAS
LOW-PRESSURE GAS
COOLING COIL
CONDENSER
OUT
IN
COMPRESSOR
HIGH-PRESSURE LIQUID
LIQUID RECEIVER
OUTSIDE

FIGURE 3.1

The wide selection of air conditioners introduces a lot of problems. First, one must check the power consumption outlets, and voltages required by the various air conditioners. Then one must be concerned about the cooling capacity of the air conditioner to insure that it meets particular needs.

One of the biggest reasons an air conditioner does not perform to expectations is that the unit is simply too small for the area being cooled. The opposite problem, of course, occurs when a person buys an extra-large air conditioner, one that has much more cooling capacity than is needed. A large unit makes too much noise, produces drafts, cools the room too quickly, or does not seem to be able to lower the humidity of the air. All of these are common problems with oversized air conditioners, proving that bigger is not always better.

A large number of people buy a room air conditioner with the idea of cooling more than one room. The problem here may be improper air circulation. Cold air is heavy and difficult to move--it has a tendency to sink next to walls and lie on the floor. A room unit can provide only limited air circulation. It has a fan to blow the air out into the room, but it has no way to really circulate the air through the house. Cool air will not circulate by itself as readily as warm air, so you have to be sure that either the air conditioner's fan is able to blow the cool air into all rooms or provide an extra fan to assist.

If the air conditioner is installed in a room that has limited circulation to other rooms--like a bedroom--the room with the air conditioner will be much cooler than the other rooms.

Using fans to help circulate the cool air can bring the air conditioner's performance up to what it should be. Fans are beneficial in another way, for the air circulating from the fans will speed up evaporation from the body and make one feel cooler. It will probably be possible to turn the thermostat on the air conditioner to a warmer setting and save some electricity by using a fan.

The performance of a room air conditioner depends a good deal on the place where it is installed. For example, if the unit is installed in a window directly opposite a door, the fan on the air conditioner is going to blow cool air out each time the door is opened. Certainly, this does not conserve energy or cool a room efficiently.

If a person wants to cool two or more rooms, it is desirable to locate the air conditioner opposite an open doorway to one of the rooms. If there is no window opposite the doorway, install the air conditioner in the wall. Also use the directional vents or louvers on the air conditioner to throw the air toward the open doorway. Not all air conditioners have movable louvers and not all movable louvers work very well, so be careful when buying an air conditioner.

The condenser (the part of the room air conditioner that extends outside the house) must have good air condition around it. The condenser is the part of the air conditioner that releases the absorbed inside heat into the surrounding outside air. If there is not good air circulation around the condenser, the heat cannot be carried away and the efficiency of the air conditioner is reduced. The condenser should not be placed in direct sunlight since the sunlight warms the condenser and makes it more difficult to disperse the heat.

Sometimes an air conditioner is installed in a wall with the condenser extending into a garage. This is not recommended, since it can create problems with both heat and air circulation. If the garage door is left closed, circulation over the condenser is reduced, and the heat from the condenser is dispersed into the garage, raising the temperature inside the garage. Unless the garage door is left open when the air conditioner is operating, the efficiency of the air conditioner will be reduced considerably.

When the condenser extends outside the house, try to avoid locations that shelter the condenser from natural wind currents. While the air conditioner does have an external fan to circulate air through the condenser, it helps to have fresh air available for good cooling. In general the cooler the air around the condenser, the more efficiently the air conditioner will perform.

Size also is very important. If an air conditioner is too small, the compressor will run continuously on hot days and still not cool the room. Conversely, if the unit is too large, the compressor will start up and cool the area so quickly that it will run only a short time. Given the large amounts of electricity needed to start an electric motor and bring the air conditioner up to normal operation, the more often the compressor motor must start, the more electricity will be wasted. Another result of short operation times is that the humidity in the room will not be lowered as much, and this means the thermostat has to be set to a lower temperature for comfort, wasting more electricity.

Window air conditioners are sized in three ratings: horsepower, Btu, and tons of refrigeration (12,000 BTU is equal to one ton of refrigeration). A one-horsepower unit provides about 8,000 Btu, depending on the efficiency of the unit.

An average-size room with good insulation will usually require a unit rated at 8,000 Btu, or 3/4 ton. A one-ton air conditioner is usually large enough to cool two rooms, while a two-ton air conditioner will usually cool four or five rooms. These estimates depend, of course, on the air circulation in the house, its construction, insulation, and location.

As a rough estimate, one will need from 2.5 to 3 Btu for each square foot of floor space in a well insulated room. Before purchasing a room air conditioner, measure the floor area of the rooms to be cooled. Also, measure the window area, and make a note of how much window area faces north, south, east, and west, if the windows are shaded. Note the number of appliances operating in the room and their wattages. Armed with these figures, estimate the right size unit for your needs. (See section of this unit which shows how to estimate cooling needs.)

Before buying a room air conditioner, check the wiring. While small room air conditioners (4,000 to 5,000 Btu capacity) are not likely to require special wiring, air conditioners rated at 6,000 Btu or more draw a considerable amount of electric current when starting up and operating. Therefore, be sure that the wiring in the home can handle the load.

Older homes often have circuits that can handle no more than 10 amperes, while most newer homes have circuits rated for 15 or 20 amperes. A 6,000 Btu air conditioner will typically require between 6 and 8 amperes, so even this relatively small unit will use a large percentage of the current capacity in one circuit of your home.

Large room air conditioners normally require 240V instead of the usual 120V found in most home outlets. The reason for this is that 240-volt operation needs only half as much current to produce the same amount of power. Air conditioners are primarily 120-volt units until their current demands approach about 12 amperes; above this they normally use 240V. In terms of cooling capacity, this transition occurs somewhere between 8,000 and 12,000 Btu, depending on the efficiency of the unit and on whether or not 240V is available. When air conditioners come in either 120V or 240V, the 240-volt unit is generally more efficient because the lower amount of current also wastes less energy in the motor wiring.

2. Central Air Conditioning Systems

A central air conditioning system operates the same as a room air conditioner, with similar components and operation. A unit merely has larger parts and capacity and is designed to cool an entire house instead of one or a few rooms.

The evaporator coil is usually cased in the furnace component. The condenser is outside the house, connected to the evaporator by copper tubing carrying the refrigerant back and forth. An alternate type is in one unit located outside the house and connected to the furnace duct system through a separate duct line. (Refer to Figure 3.1 for an illustration of the components discussed.)

In addition to the thermostat control on a single basis, some adjustment in thermostats with manual overrides for specialty thermostats in rooms where zonal living options are used should be considered if one is developing an integrated conservation package. In zonal living, internal insulation and thermal barriers are used to keep heat flow from the rooms being occupied to the nonoccupied rooms to a minimum. This is a fairly complex concept because one must be sure that water pipes and other internal objects that freeze are isolated or kept within the zonal living area of optional use so that they do not freeze on sudden or great temperature drops. This means that even though the internal rooms may be allowed

C. SIZING A COOLING SYSTEM

FIGURE 3.2

DESIGN TEMPERATURES FOR AIR CONDITIONING
(OUTSIDE DRY- AND WET-BULB TEMPERATURES)

STATE AND CITIES	SUMMER DB	SUMMER WB
TEXAS		
ABILENE	95	74
AMARILLO	95	72
AUSTIN	100	78
BROWNSVILLE	95	80
CORPUS CHRISTI	95	80
DALLAS	100	78
DEL RIO	100	78
EL PASO	100	69
FORT WORTH	100	78
GALVESTON	95	80
HOUSTON	95	80
PALESTINE	100	78
PORT ARTHUR	95	80
SAN ANTONIO	100	78
WACO	100	78

As with a heating system, "sizing" means simply the selection of cooling equipment that will have the right capacity (in Btu) to properly cool a home. If a forced-air heating system is already installed, adding central cooling for summer use will be simple because the necessary ductwork, is already in place. The only additional equipment to be selected will be the refrigeration unit. However, if installing just a central cooling system (without central heat) is desired, the installation must also include the necessary ductwork and registers.

Many people believe that comfort cooling calls for just lowering the house temperature by 12° to 15° below the outdoor temperature. This is an error.

Regardless of the outdoor temperature in summer, the indoor temperature should be in the neighborhood of 78°, and the relative humidity should be about 50%.

to drop to 40-45°F it is possible for water pipes in outer walls in areas where the temperature drops to below zero to freeze under this option. This is especially true where one has gone for heavy insulation. The thermostat control for zonal living means that a person does one of two things: (1) turn the main thermostat down and adjust the registers according to some predetermined plan to maintain a desired room or rooms at a fixed temperature as a function of what the temperature would be at the thermostat under this option. This involves a lot of trial and error with respect to setting thermostats and taking temperatures. However, if time is not of essence and money is not available this is the viable option. (2) The other viable option is to set thermostats into certain rooms to shut registers and by the use of simple switches to move the controlling thermostat from one place to another in effect. Actually, what you have is three or four installed thermostats at a switching mechanisms tells the furnace which ones it is to sense. This is an electronic problem which may be solved by the homeowner, but if the homeowner does not have expertise in this area, he should approach someone who works on these types of situations.

Another option for thermostat control is to adjust thermostats so that the temperature swings between the time the thermostat shuts off and comes back on is increased to 3-4°. This is very important in spring and fall and will lengthen the duty cycles and thus also the time between duty cycles.

If the weather is any hotter or more humid than this, the overwhelming majority of people will feel distinctly warm and uncomfortable, whether the outdoor temperature is 85°F or 100°. Thus, 75°F and 50% relative humidity is said to be the ideal air condition for almost all air conditioned spaces, including houses.

Home cooling systems should have enough capacity to provide this much cooling and dehumidifying at all times. Thus, a larger cooling unit will be needed for a house in Phoenix, where summer temperatures often climb to 105°, than is needed for an identical house in Chicago, where outside temperatures seldom exceed 95°F. It also means that more capacity is needed in a humid area like New Orleans than in a drier area, like Chicago, having the same dry-bulb temperature.

The fact that 75°F and a 50% relative humidity are required for bodily comfort in summer is based on staying in an air conditioned space for one or two hours or more. The same condition may feel overly cool when one first enters an air conditioned store or restaurant. The longer one stays, however, the more the body adjusts.

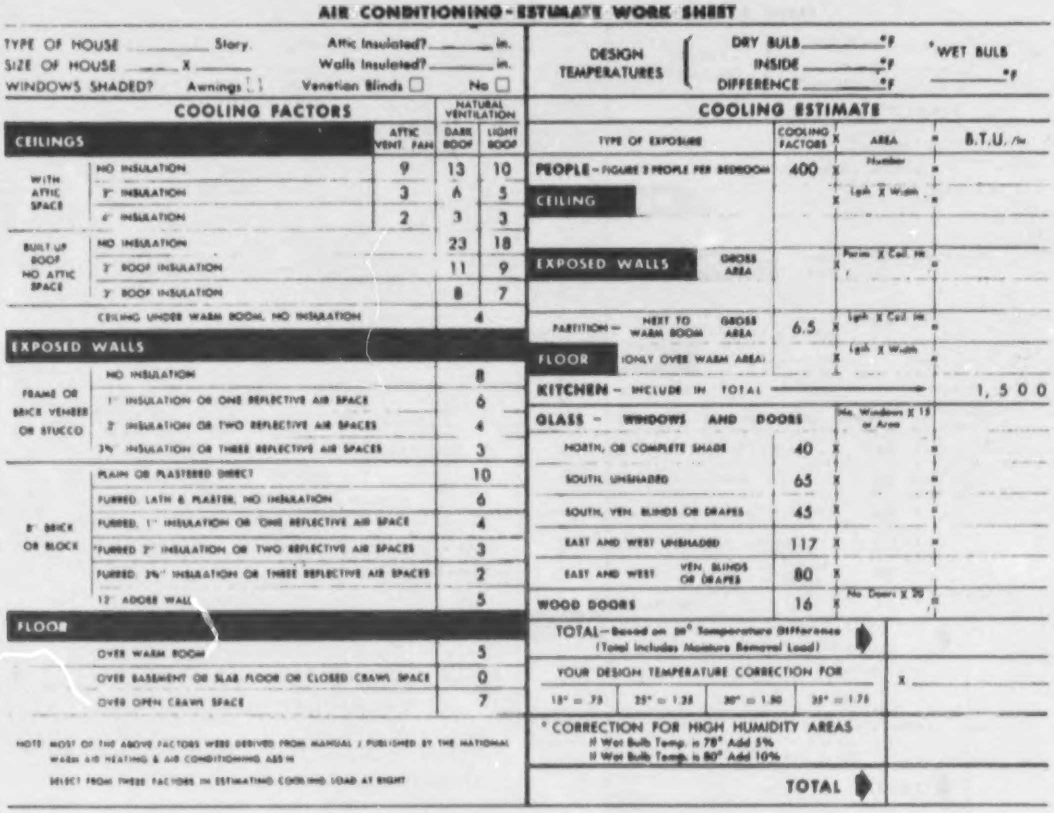
Therefore, it is a mistake to settle for a small air conditioner that can lower the indoor temperature to 80° only, or reduce indoor heat by only 12° to 15° below the outdoor temperature.

Each geographical location has a design temperature for cooling. This is not the highest temperature recorded ..it is the recommended high (dry-bulb) temperature on which to base practical cooling requirements. Find the design ("Summer DB") temperature for your area at Figure 3.2.

The same chart also lists wet-bulb ("Summer WB") temperatures...which indicate the prevailing humidity conditions. In any area where the WB temperature does not exceed 75°, do not worry about the humidity; but if it does exceed 75°, increase the cooling unit capacity for proper humidity control.

A worksheet is shown as Figure 3.3. You will need the same "tools" as for calculating heat requirements.

There is only one ceiling, the one at the top of the space to be cooled. In the case of an entire house, this ceiling may have an attic above it...or may be one without an attic. In the case of a first-floor apartment, there is no ceiling if the floor above is cooled...but you do count the ceiling if the floor above is not cooled and there is no insulation between. This same rule applies to the floor of a second-floor apartment; but in the case of a whole house, the floor is counted only when there is an open crawl space (does not count if over a basement, enclosed crawl space, or on a slab).



AIR CONDITIONING - ESTIMATE WORK SHEET

TYPE OF HOUSE ________ Story. Attic Insulated? ________ in.
SIZE OF HOUSE ____ X ____ Walls Insulated? ________ in.
WINDOWS SHADED? Awnings ☐ Venetian Blinds ☐ No ☐

DESIGN TEMPERATURES: DRY BULB ________ °F, INSIDE ________ °F, DIFFERENCE ________ °F; *WET BULB ________ °F

COOLING FACTORS

		ATTIC VENT. FAN	NATURAL VENTILATION DARK ROOF	NATURAL VENTILATION LIGHT ROOF
CEILINGS				
WITH ATTIC SPACE	NO INSULATION	9	13	10
	2" INSULATION	3	6	5
	4" INSULATION	2	3	3
BUILT UP ROOF NO ATTIC SPACE	NO INSULATION		23	18
	1" ROOF INSULATION		11	9
	2" ROOF INSULATION		8	7
	CEILING UNDER WARM ROOM, NO INSULATION		4	
EXPOSED WALLS				
FRAME OR BRICK VENEER OR STUCCO	NO INSULATION		8	
	1" INSULATION OR ONE REFLECTIVE AIR SPACE		6	
	2" INSULATION OR TWO REFLECTIVE AIR SPACES		4	
	3⅝" INSULATION OR THREE REFLECTIVE AIR SPACES		3	
8" BRICK OR BLOCK	PLAIN OR PLASTERED DIRECT		10	
	FURRED, LATH & PLASTER, NO INSULATION		6	
	FURRED, 1" INSULATION OR ONE REFLECTIVE AIR SPACE		4	
	FURRED 2" INSULATION OR TWO REFLECTIVE AIR SPACES		3	
	FURRED, 3⅝" INSULATION OR THREE REFLECTIVE AIR SPACES		2	
	12" ADOBE WALL		5	
FLOOR				
	OVER WARM ROOM		5	
	OVER BASEMENT OR SLAB FLOOR OR CLOSED CRAWL SPACE		0	
	OVER OPEN CRAWL SPACE		7	

NOTE: MOST OF THE ABOVE FACTORS WERE DERIVED FROM MANUAL J PUBLISHED BY THE NATIONAL WARM AIR HEATING & AIR CONDITIONING ASS'N

SELECT FROM THESE FACTORS IN ESTIMATING COOLING LOAD AT RIGHT

COOLING ESTIMATE

TYPE OF EXPOSURE	COOLING FACTORS	X	AREA	=	B.T.U./hr
PEOPLE - FIGURE 2 PEOPLE PER BEDROOM	400	X	Number	=	
CEILING		X	Lgth X Width	=	
EXPOSED WALLS GROSS AREA		X	Perim. X Ceil. ht.	=	
PARTITION - NEXT TO WARM ROOM GROSS AREA	6.5	X	Lgth X Ceil. ht.	=	
FLOOR (ONLY OVER WARM AREA)		X	Lgth X Width	=	
KITCHEN - INCLUDE IN TOTAL →					1, 5 0 0
GLASS - WINDOWS AND DOORS			No. Windows X 15 or Area		
NORTH, OR COMPLETE SHADE	40	X		=	
SOUTH, UNSHADED	65	X		=	
SOUTH, VEN. BLINDS OR DRAPES	45	X		=	
EAST AND WEST UNSHADED	117	X		=	
EAST AND WEST VEN. BLINDS OR DRAPES	80	X			
WOOD DOORS	16	X	No. Doors X 20	=	

TOTAL—Based on 20° Temperature Difference (Total Includes Moisture Removal Load) ➧	
YOUR DESIGN TEMPERATURE CORRECTION FOR 15° = .75 | 25° = 1.25 | 30° = 1.50 | 35° = 1.75	X ________
* CORRECTION FOR HIGH HUMIDITY AREAS If Wet Bulb Temp. is 78° Add 5% If Wet Bulb Temp. is 80° Add 10%	
TOTAL ➧	

FIGURE 3.3

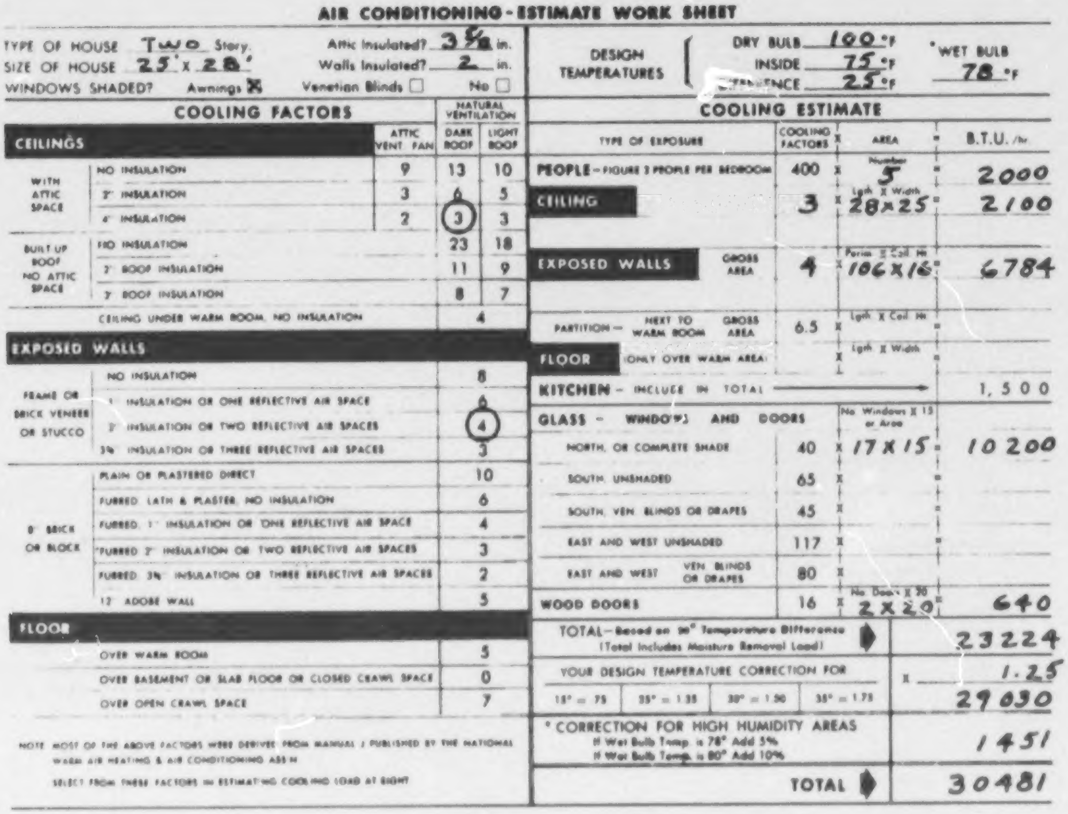
The gross area of exposed walls is the house perimeter times the above-ground wall height. Windows and doors are simply counted (as for heating calculation)...except that you will count those on each side of the house (north, south, etc.) separately, and you must also consider whether or not each window is normally shaded (by blinds, drawn draperies, etc.). People (house occupants, at two per bedroom) must also be counted, as shown on the worksheet.

Multiply each of the above by the proper "COOLING FACTOR" listed on the form. Add these together with the 1,500 (Btu) listed for your kitchen to arrive at a total (you can scratch this off if kitchen is entirely separate from area to be cooled). If your DV temperature does not exceed 75°, this total is the cooling unit capacity (in Btu) needed to maintain a 75° inside temperature. However, if your DB temperature exceeds 95°F, or if you want an inside temperature lower than 75°, first figure the difference between your DB temperature and the desired inside temperature, then substract 20 from this to learn how many more degrees of cooling you will need. Now add to the above total the amount indicated under "YOUR DESIGN TEMPERATURE CORRECTION FOR" on the work sheet (e.g., if you need 15° more cooling, you must add 3/4 of above total; for 25° more, add 1-1/4, etc.) Finally, if your WB temperature exceeds 75°, you must add still more (5% of the first total if it is 78°; 10% if it is 80°) to be able to maintain an inside relative humidity of 50%.

D. MAINTENANCE AND USE

The efficiency with which an air conditioner can dehumidify the air depends primarily upon how cold the evaporator coil gets. If the fan of the air conditioner is set at a low speed, the coil will

Figures 3.4 and 3.5 illustrate how to use the worksheet for estimating cost requirements for a sample house. Study the example before preparing your worksheet.



AIR CONDITIONING - ESTIMATE WORK SHEET

TYPE OF HOUSE Two Story.
SIZE OF HOUSE 25' x 28'
WINDOWS SHADED? Awnings ☒ Venetian Blinds ☐ No ☐
Attic Insulated? 3 5/8 in.
Walls Insulated? 2 in.

DESIGN TEMPERATURES: DRY BULB 100 °F; INSIDE 75 °F; DIFFERENCE 25 °F
*WET BULB 78 °F

COOLING FACTORS

		ATTIC VENT FAN	NATURAL VENTILATION DARK ROOF	NATURAL VENTILATION LIGHT ROOF
CEILINGS				
WITH ATTIC SPACE	NO INSULATION	9	13	10
	2" INSULATION	3	6	5
	4" INSULATION	2	[✓ 3]	3
BUILT UP ROOF NO ATTIC SPACE	NO INSULATION		23	18
	2" ROOF INSULATION		11	9
	3" ROOF INSULATION		8	7
	CEILING UNDER WARM ROOM, NO INSULATION		4	
EXPOSED WALLS				
FRAME OR BRICK VENEER OR STUCCO	NO INSULATION		8	
	1" INSULATION OR ONE REFLECTIVE AIR SPACE		6	
	2" INSULATION OR TWO REFLECTIVE AIR SPACES		[✓ 4]	
	3½" INSULATION OR THREE REFLECTIVE AIR SPACES		3	
8" BRICK OR BLOCK	PLAIN OR PLASTERED DIRECT		10	
	FURRED, LATH & PLASTER, NO INSULATION		6	
	FURRED, 1" INSULATION OR ONE REFLECTIVE AIR SPACE		4	
	FURRED 2" INSULATION OR TWO REFLECTIVE AIR SPACES		3	
	FURRED, 3½" INSULATION OR THREE REFLECTIVE AIR SPACES		2	
	12" ADOBE WALL		5	
FLOOR				
	OVER WARM ROOM		5	
	OVER BASEMENT OR SLAB FLOOR OR CLOSED CRAWL SPACE		0	
	OVER OPEN CRAWL SPACE		7	

NOTE: MOST OF THE ABOVE FACTORS WERE DERIVED FROM MANUAL J PUBLISHED BY THE NATIONAL WARM AIR HEATING & AIR CONDITIONING ASS'N
SELECT FROM THESE FACTORS IN ESTIMATING COOLING LOAD AT RIGHT

COOLING ESTIMATE

TYPE OF EXPOSURE	COOLING FACTORS	x	AREA	=	B.T.U./hr
PEOPLE - FIGURE 2 PEOPLE PER BEDROOM	400	x	Number 5	=	2000
CEILING	3	x	Lgth x Width 28x25	=	2100
EXPOSED WALLS GROSS AREA	4	x	Perim x Ceil Ht 106x16	=	6784
PARTITION - NEXT TO WARM ROOM GROSS AREA	6.5	x	Lgth x Ceil Ht	=	
FLOOR (ONLY OVER WARM AREA)		x	Lgth x Width	=	
KITCHEN - INCLUDE IN TOTAL →					1, 5 0 0
GLASS - WINDOWS AND DOORS			No Windows x 15 or Area		
NORTH, OR COMPLETE SHADE	40	x	17x15	=	10 200
SOUTH, UNSHADED	65	x		=	
SOUTH, VEN. BLINDS OR DRAPES	45	x		=	
EAST AND WEST UNSHADED	117	x		=	
EAST AND WEST VEN. BLINDS OR DRAPES	80	x		=	
WOOD DOORS	16	x	No Doors x 20 2x20	=	640
TOTAL - Based on 20° Temperature Difference (Total Includes Moisture Removal Load) ◆					23224
YOUR DESIGN TEMPERATURE CORRECTION FOR 15° = .75 / 25° = 1.25 / 30° = 1.50 / 35° = 1.75					x 1.25 29030
* CORRECTION FOR HIGH HUMIDITY AREAS If Wet Bulb Temp. is 78° Add 5% If Wet Bulb Temp. is 80° Add 10%					1451
TOTAL ◆					30481

DETERMINING THE COOLING FOR A SAMPLE HOUSE

Enter your information and calculations on the Work Sheet as shown following:

PEOPLE This 3-bedroom home will normally house 5 people, which multiplied by the factor "400", gives a cooling load of 5 x 400 or 2000 BTU/Hr.

CEILING The area is length of house times width (28 x 25) or 700 sq. ft. The ceiling cooling factor, for a dark color roof and attic space with between 2-in. and 4-in. insulation, is "3". The load then is 700 x 3 or 2100 BTU/Hr.

FIGURE 3.4

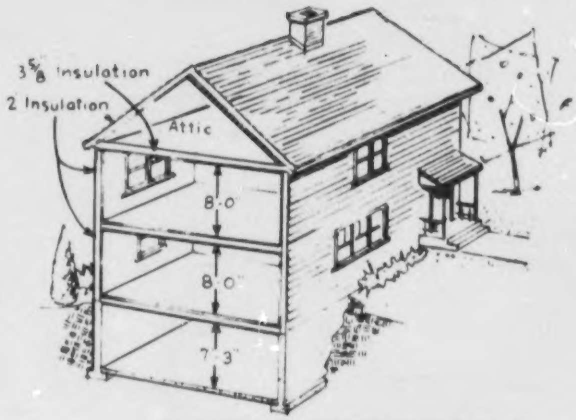
HOUSE SPECIFICATIONS

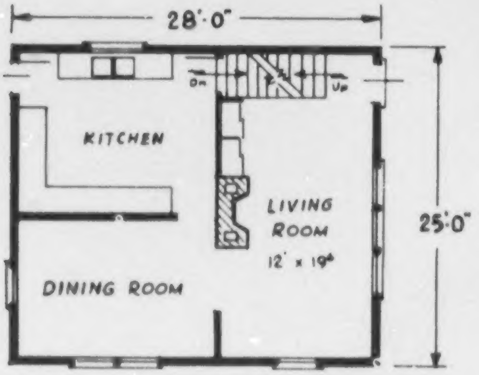
DESIGN TEMPERATURES

100° Dry Bult – 75° Inside = 25° Difference

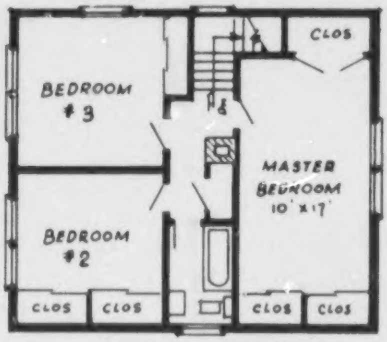
78° Wet Bulb Temp.

Roof	Dark Color
Walls	Frame With 2" Insulation
Ceiling	With Attic and 3-5/8" Insulation
Windows	All North or With Awnings
Basement	Under Entire House





FIRST FLOOR



SECOND FLOOR

EXPOSED WALLS Total area of exposed walls is perimeter of house times ceiling height (of upper ceiling). This is 106 (25+28+25+28) times 16 (2 stories) or 1,696 sq. ft. The cooling factor table shows frame walls with 2-in. insulation has the factor "4". Multiplying 1,696 sq. ft. by 4 gives a load of 6,784 BTU/Hr.

FLOOR Over basement . . . no factor required.

WINDOWS House has 17 windows, either facing north or completely shaded by awnings. This means that all windows will have a cooling factor of "40". First, multiply the 17 windows by "15" for glass area (17 x 15 = 255), then by 40 (255 x 40 = 10,200). This means that the cooling load for glass is 10,200 BTU/Hr.

WOOD DOORS The 2 wood doors to the outside are multiplied by "20" for area (2 x 20 = 40), then by the indicated factor "16" (40 x 16 = 640) for a load of 640 BTU/Hr.

KITCHEN A standard load of 1,500 BTU/Hr. is added for kitchen activities.

TOTAL COOLING LOAD (based on 20° temperature difference) This is the total of the preceding individual loads. In this example, it is 2,000 + 2,100 + 6,784 + 10,200 + 640 + 1,500 or 23,224 BTU/Hr.

DESIGN TEMPERATURE CORRECTION An allowance must be made because the difference between the outside dry bulb temperature (100°) and the desired inside temperature (75°) is greater than 20°. The Work Sheet indicates that a difference of 25° (100° – 75°) requires a correction factor of 1.25. The adjusted cooling load (23,224 x 1.25) then becomes 29,030 BTU/Hr.

HIGH HUMIDITY CORRECTION This area has a wet bulb reading of 78°. The Work Sheet indicates that under such conditions, 5% must be added to the cooling load (29,030 x .05 = 1451; 29,030 + 1451 = 30,481). The final cooling load then becomes 30,481 BTU/Hr.

FIGURE 3.5

get colder and more moisture will be removed from the air; however, the air conditioner may not be able to cool the house enough on especially hot days. At high fan speeds, the air conditioner will be able to cool better, but it will not be able to dehumidify as well. For best comfort, it is humid days and a high fan setting on hot days.

Constantly adjusting the thermostat up and down does no good. An air conditioner will not cool a room any faster if the thermostat is set to a much cooler setting when it is first turned on. The compressor turns on when the thermostat senses that the room is too warm, and does not turn off until the room temperature reaches the setting on the thermostat. The fastest way to cool a room is to set the fan speed on high. This will make the air conditioner work at maximum capacity. Set the thermostat at a comfortable temperature, then leave it alone, except for minor changes to take care of cool or hot days. In general, an air conditioner with several fan speeds will permit the room to be kept at a more uniform temperature without having to adjust the thermostat as much.

Should one open up the house during the day when not at home? This is not a good idea if one lives in a climate with humid summers. If the house is closed during the day, the temperature inside may increase, but the humidity will not-it will decrease. The temperature inside a sealed home will not become much hotter than the outside temperature. This will permit the air conditioner to cool faster, and it will save electricity as well. As a general rule, if the humidity of the outside air is more than 30% it will be more economical to close up the house when leaving in the morning. The inside temperature may get as hot as the outdoors, but the lower humidity inside makes the home feel much cooler.

There are many things one can do to keep the air conditioning operating at peak efficiency. An air conditioner has filters that get clogged with dust, finned coils that become dirty, and motors that need lubricating. These simple tasks are not difficult to do and require only a wrench and a couple of screwdrivers.

All air conditioners should be lubricated and cleaned each year. The best time for doing this is a month or so before the summer cooling season begins.

As room air is drawn into the air conditioner, it first passes through a foam or aluminum mesh filter much like the air filters in many furnaces. The air filters are cleanable, and they should be cleaned several times a year.

The evaporator coil at the front of the air conditioner rarely needs attention; the cleaning action of water condensing on it usually does a good job of keeping it free of dirt. However, one should routinely inspect this coil whenever cleaning the air filter. If the air filter has moved or allowed much dirt to pass through, sections of the evaporator coil may require some cleaning. After several years of use, some sections of the coil are bound to accumulate dirt.

If the thermostat on an air conditioner is set at a very low temperature, the evaporator coil may begin to collect ice. What happens is that the temperature of the evaporator drops below the freezing point and ice begins to form on the evaporator. Ice usually starts to form along the refrigerant inlet at the top of the coil, and it gradually progresses downward until the whole coil is blocked with ice. Since the formation of ice restricts the flow of air through the evaporator coil, the more ice that forms, the colder the coil will get, and this causes even more ice to form.

The common reason for the evaporator icing up is that the thermostat is set at too low a temperature. When the thermostat is set properly, the room will stay at a fairly comfortable and uniform temperature.

The moisture that collects on the evaporator drains back to a pan under the condenser coil. There, a ring on the fan blade often picks up the water and slings it onto the condenser. This technique increases the efficiency of the air conditioner because the evaporating water helps cool the condenser coil.

The condenser collects much more dirt than the evaporator. At most, a wire screen is used to keep out leaves and other large objects, but this still lets plenty of dirt and trash through to the condenser. To do a good cleaning job, remove the air conditioner case so it is possible to get at all the inside parts.

Air conditioners normally have two motors: one for the fan and the other for the compressor. In this way, the fan motor can run constantly to circulate air in the room, while the compressor motor need only run when the thermostat calls for more cooling. The fan motor may be single- or double-shafted, depending on how the fan blades are connected to the motor. The most usual arrangement is the double-shafted motor, in which the shaft extends from each end of the motor. A large fan blade is connected to one shaft of the motor to circulate air over the outside condenser coil. The other end of the shaft extends through a panel to a squirrel cage fan that circulates air over the evaporator coil and into the room. The advantage in using a squirrel cage fan on the inside is that it is much quieter in operation.

During the yearly tuneup, clean the fan motor and fan blades (particularly the condenser fan blades). The fan motor should also be oiled though some of the newer fans have sealed bearings that do not require oiling every year.

Once a year, clean out the parts of a central air conditioner, the same as for a room air conditioner. The air filter should be cleaned or replaced about once a month. When the evaporator coil is located in the coil case of the furnace, the central air conditioner uses the furnace fan, so this fan will require more frequent inspection and cleaning. With the alternate, single-unit system, the central air conditioner contains a separate fan to force cool air into the furnace duct system. Electrically heated homes may use this alternate system with duct work just for air conditioning.

Grass, leaves, and dirt may collect in the condensing unit located outside the house. Be sure to remove any restrictions that could reduce the efficiency of the unit or impair its operation.

E. DEHUMIDIFY IN SUMMER

Summer discomfort is largely caused by high humidity. The excess water content of the air prevents sweat from evaporating and thus diminishes the body's natural cooling effect.

Removing excess water from the air in homes is possible without resorting to the expense of air conditioning. A dehumidifier is an apparatus that draws room air over a cooling coil where it loses moisture. Water is removed by condensation on cold coils. It is then heated slightly and returned by fan.

When shopping for a unit, look for the water removal capacity rating of the Association of Home Appliances Manufacturers. Humidifiers can range in price from $90 (with a water removal capacity of eleven pints a day) to $150 (with a 30 pint capacity and convenience features). The electrical operating rate can change from $.20 to $.50 per day. Operating costs are reduced when an area has been sufficiently dried and the machine does not have to run steadily.

For Safe, Efficient Operation

- Read the owner's manual.
- Place the unit at least 6 inches (15cm) from the nearest wall for free air flow.
- Close all doors and windows in the area to be dried.
- For the first few days, turn the humidistat to "Drier" or "Extra Dry."
- Turn the machine OFF and disconnect power cord before emptying the water pans; be sure the area and unit are dry before reconnecting the cord.
- On cool days, check the cold coils for frosting; if frosting occurs, turn OFF the unit until melted.
- Always unplug the cord before cleaning the unit; dust the grills and wipe the cabinet.
- Every few weeks, clean the inside of the water container with a soft cloth and a mild detergent to prevent mold, mildew, and bacteria.
- Once a month, dust the lint from the cold coils.

F. TIPS FOR COOLING ENERGY SAVERS

The following tips for cooling energy savers are from the U.S. Department of Energy and serve as a convenient summary for the points discussed in this unit.

-Overcooling is expensive and wastes energy. Don't use or buy more cooling equipment capacity than is actually needed.

-If central air-conditioning is needed, select the smallest and least powerful system that will cool the home adequately. A unit larger than needed only costs more to run but probably won't remove enough mooisture from the air.

-Ask the dealer to help determine how much cooling power is needed for the space to be cooled and for the local climate. (For further information, see page 19, Energy Efficiency Ratios.)

-Make sure the ducts in the air-conditioning system are properly insulated, especially those that pass through the attic or other uncooled spaces. This could save almost 9 percent in cooling costs.

-If central cooling is not needed, consider using individual window or through-the-wall units in rooms that need cooling from time to time. Select the smallest and least powerful units for the rooms to be cooled. As a rule, these will cost less to buy and less to operate.

-Install a whole-house ventilating fan in the attic or in an upstairs window to cool the house when it's cool outside, even if there is a central unit.

-It will pay to use a fan rather than mechanical cooling when the outside temperature is below 82°F. When windows are open, the fan will pull cool air through the house and exhaust warm air through the attic.

When using air conditioning...

-Set the thermostat at 78°F, a reasonably comfortable and energy-efficient indoor temperature.

-The higher the setting and the less difference between indoor and outdoor temperature, the less outdoor hot air will flow into the building.

-If the 78°F setting raises the temperature 6 degrees (from 72°F to 78°F, for example), between 12 and 47 percent can be saved in cooling costs, depending on location of the house.

-Don't set the thermostat at a colder setting than normal when turning the air-conditioner ON. It will NOT cool faster; it WILL cool to a lower temperature than needed and will use more energy.

-Set the fan speed on HIGH except in very humid weather. When it's humid, set the fan speed at low; there will be less cooling but more moisture will be removed from the air.

-Clean or replace filters at least once a month. When the filter is dirty, the fan has to run longer to move the same amount of air, and this takes more electricity.

-Turn off window air conditioners when leaving a room for several hours. Less energy will be used cooling the room later than if the unit is left running.

-Consider using a fan with window air conditioner to spread the cooled air farther without greatly increasing your power use; But be sure the air conditioner is strong enough to help cool the additional space.

-Never place lamps or TV sets near the thermostat. Heat from these appliances is sensed by the thermostat and could cause the air conditioner to run longer than necessary.

With or without cooling...

-Keep out daytime sun by placing vertical louvers or awnings on the outside of windows, or draw draperies, blinds, and shades indoors. Heat gain from the sun can be reduced by as much as 80 percent this easy way.

-Keep lights low or OFF when possible. Electric lights generate heat and add to the cooling load.

-Do cooking and use other heat-generating appliances in the early morning and late evening hours whenever possible.

-Open the windows instead of using the air conditioner or electric fan on cooler days and during cooler hours.

-Turn OFF the furnace pilot light in summer, but be sure it's reignited before turning the furnace ON again.

-Dress for the warmer indoor temperatures. Neat but casual clothes of lightweight openweave fabrics are most comfortable.

-A women will feel cooler in a lightweight skirt instead of slacks. A man will feel cooler in a short-sleeved shirt than in a long-sleeved shirt of the same weight fabric.

Without air conditioning...

-Be sure to keep windows and outside doors closed during the hottest hours of the day.

-Use windows or whole-house ventilation fans to cool the house when it's cool outside.

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

UNIT IV

DUCT WORK

UNIT OBJECTIVES

1. Calculate duct size needed to supply conditioned air to various rooms in a home.

2. Distinguish between types of ducts and duct material.

3. Discuss the operating specifications of ducts and registers.

4. Discuss various duct piping arrangements for certain types of building constructions:

   a. Extended Plenum System
   b. Radial Piping System

5. Recognize the importance of duct insulation.

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

UNIT IV

DUCT WORK

LECTURE

INTRODUCTION:

In a central air conditioning (heating or cooling) system, the delivery system for the conditioned air is through duct work.

The specific type of duct system used depends upon the type of structure, the equipment location, and the layout of the building. Ideally, the furnace should be located near the center of the house. This will eliminate long runs of ducts, which is more important since conditioned air passing through long ducts will lose or gain considerable heat before reaching its distination. Also, long ducts increase the incidence of friction between the air and the sides of the ducts which causes more energy loss.

Single-story houses may have the ductwork terminating in registers delivering air from either the floor, walls or the ceiling. However, it is recommended that overhead distribution be used only in mild winter climates unless some provision is made to heat the floors in a cold climate.

A. CALCULATION OF DUCT SIZE

Duct sizes are determined according to airflow rates in CFM (cubic feet per minute). Size is determined by the amount of air that is required to either heat or cool a room. The general formula is $S/sf = \frac{v}{A/F}$ where S is the size in square feet, V is the volume of

ACTIVITIES

Show how warm air rises--cold air falls--by using thermometers at different heights! Diagram this.

air required and A/F is the air flow in feet per minute (usually 600 fpm in the average room). V is determined by several factors, including heat loss temperature of the air coming off the furnace or air conditioner, and the overall volume of the room. Generally speaking, air conditioning ducts must be larger than heating ducts. Ducts are commonly rectangular or circular in cross section, and are usually designed for velocities of 150 to 1,500 feet per minute (fpm).

Cost of duct work varies. As a rule of thumb, at present prices, ductwork is estimated at $75-$100 per room register.

B. TYPES OF DUCTS

Ducts are usually made of one of the following materials:

Galvanized steel sheet
Black-iron sheet
Stainless-steel sheet
Aluminum sheet
Fibrous glass sheet

Heating ducts are usually 6" in diameter and cooling ducts 8".

The common functions of ducts and their operating specifications are:

Air intake from outside	500-1200 CFM
Air washers (dust removers)	500- 600 "
Branch ducts and risers	500-1800 "
Exhaust risers	500-1800 "
Heater corrections	700-1400 "
Humidifiers	500- 600 "
Main Exhaust ducts	900-1500 "
Main Ventilating ducts	500-1500 "
Supply grilles near floor	150- 250 "
Supply openings	350- 500 "
Supply registers and grilles	250- 450 "

C. DUCT SYSTEM DESIGNS

There are several techniques to consider in designing a good energy-saving duct system. Sharp turns should be eliminated when possible in order to cut down on pressure losses that will occur when fast-moving air is forced to turn a corner. Turning vanes should be installed inside elbows where sharp turns are necessary.

Ducts should be properly sized for the blower. If undersized, the air will move too fast through the ducts causing unwanted noise and excessive losses due to air friction along the duct walls. Long runs of ducts should be eliminated also to avoid friction losses.

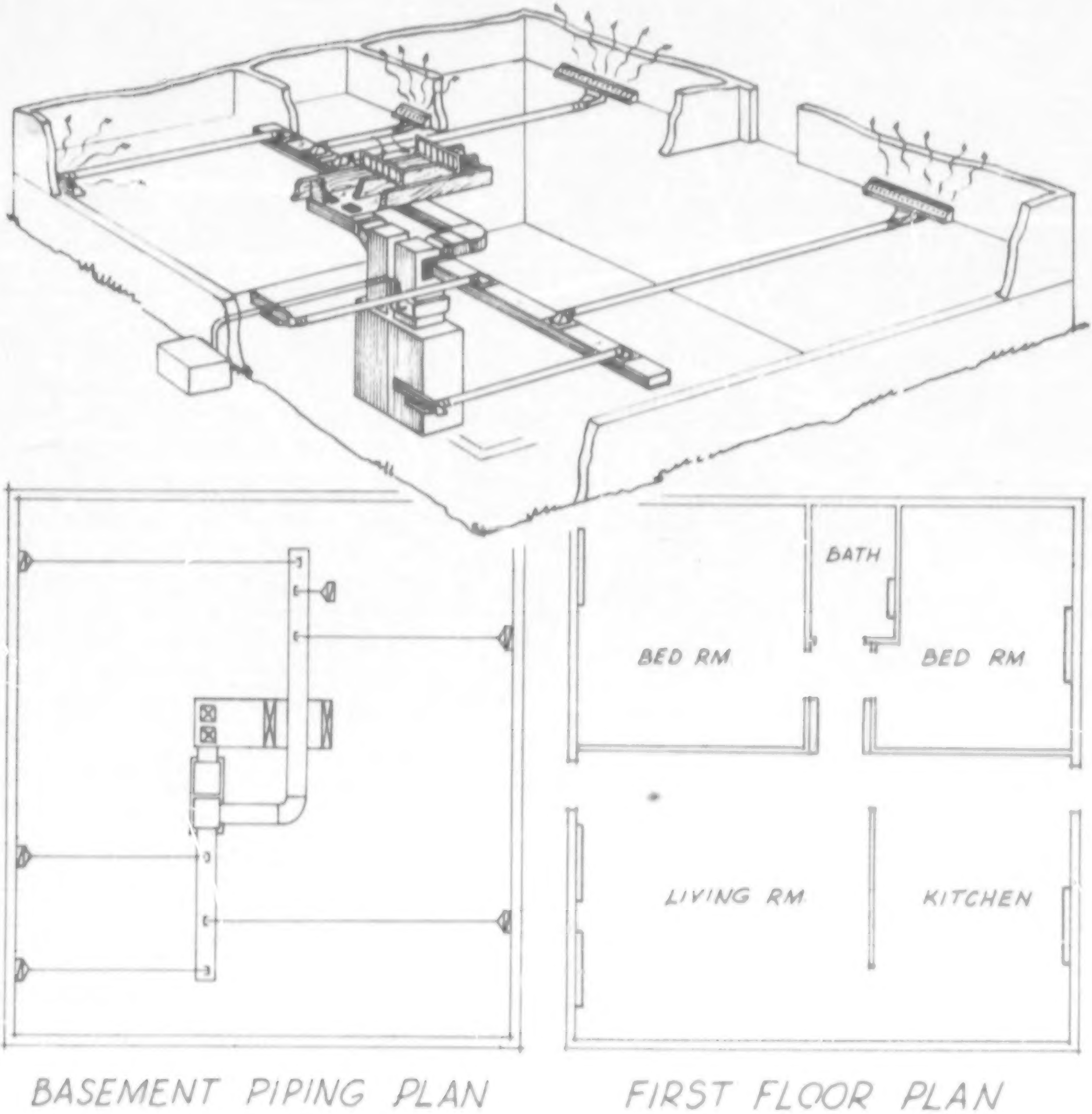
Location of the vents is also important. In a home where heating is the most important consideration due to long cold winters, warm air should enter the room near the floor so that the heat will rise by convection. The return air vents should be placed high on the walls and on opposite sides of the room. This allows the incoming warm air to rise from the floor and travel across the room.

Zoning of heating and cooling systems almost always provides the opportunity for lower energy consumption, since each zone can be maintained at the temperature required, without regard to the temperatures in other zones. Zoning also provides the owner with the opportunity to cut back on the heating and/or cooling to any rooms not being used. Tests have shown that zoning can achieve energy savings of 20 percent and more.

Figures 4.1 - 4.11 show various duct piping arrangements for certain types of building constructions.

EXTENDED PLENUM SYSTEM

The extended plenum system usually is preferred for basement installation because of its neat appearance. Branch pipes to outlets may be round or rectangular and are run between or beneath basement joists. The extended plenum is usually required for larger installations.

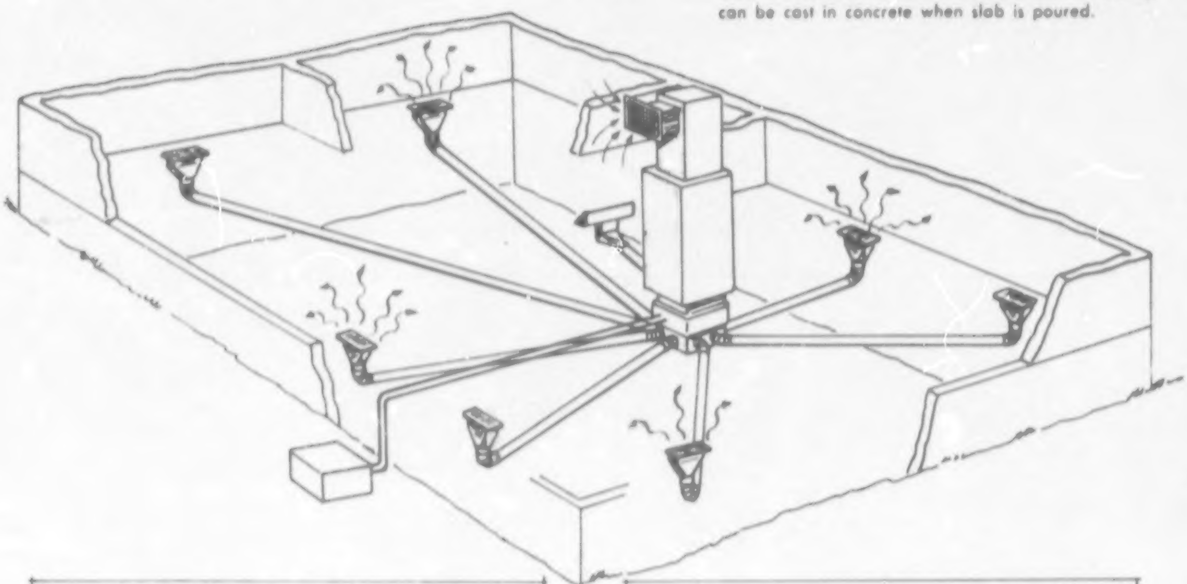


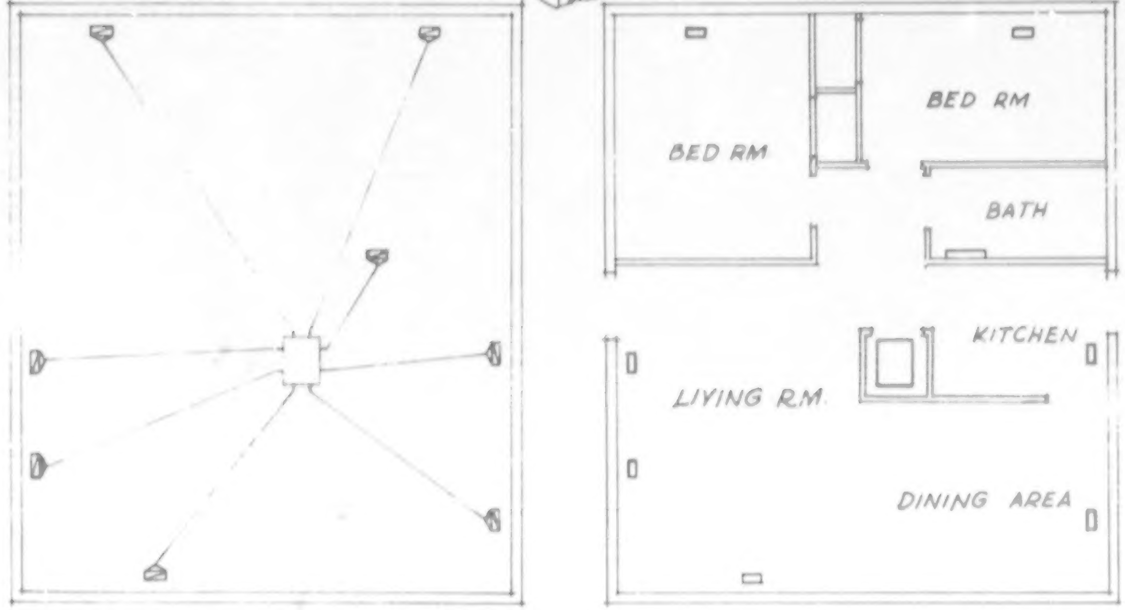
BASEMENT PIPING PLAN FIRST FLOOR PLAN

FIGURE 4.1

RADIAL PIPING SYSTEM, COUNTERFLOW FURNACE

This combination is widely used in compact, one-story houses with crawl space. Warm air plenum under furnace extends into crawl space, where pipes to supply outlets are run beneath joists. Supply pipes and plenum should be insulated. Similar system is used with slab construction where plenum and piping can be cast in concrete when slab is poured.





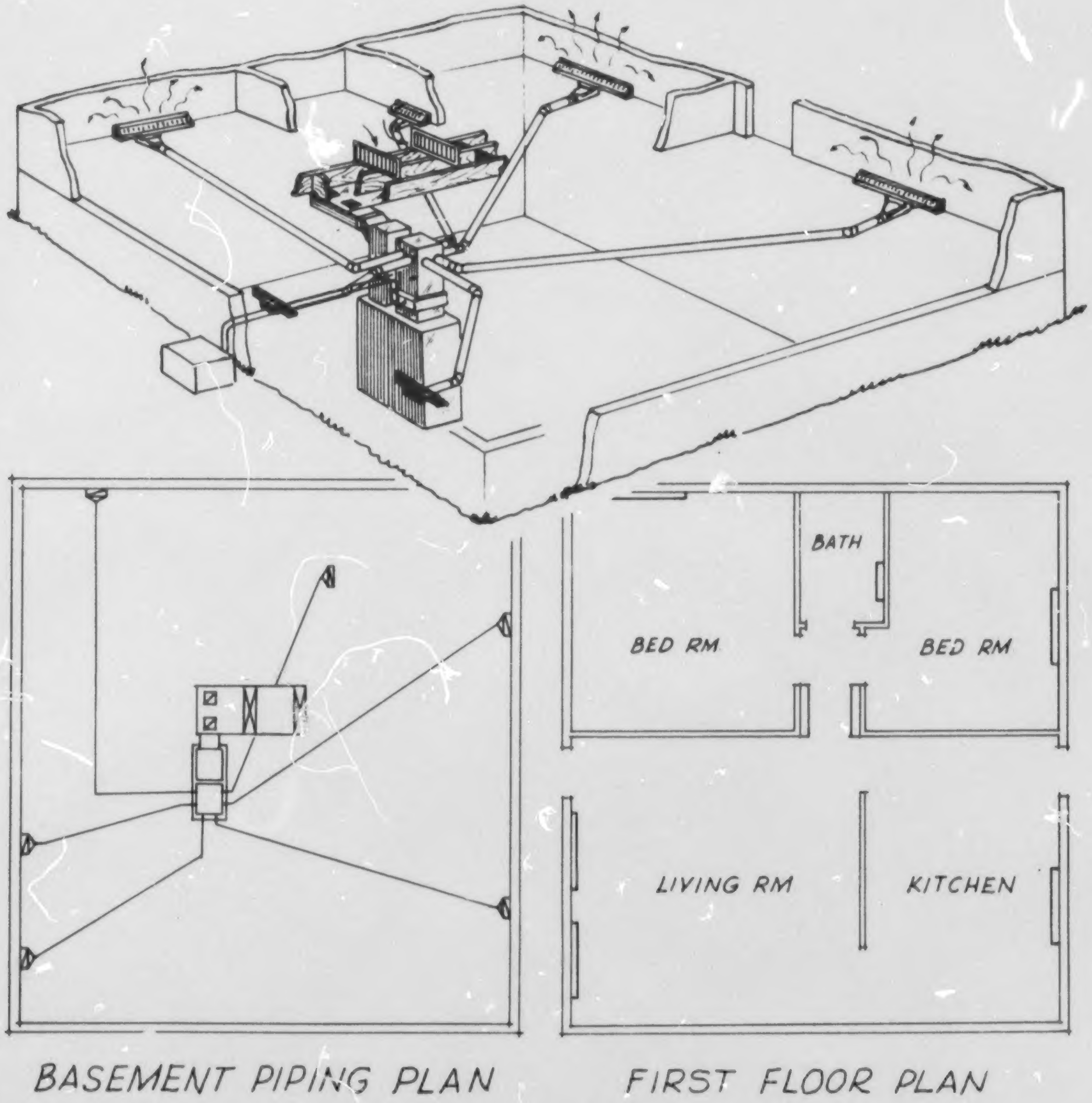
CRAWL SPACE PIPING PLAN

FIRST FLOOR PLAN

FIGURE 4.3

RADIAL PIPING SYSTEM

This method of piping can be used where length of individual pipe runs does not exceed limits of pipe capacity and where appearance is not a factor. Pipes are suspended from basement joists and run in as direct a line as possible from plenum to outlet connection. Requires a minimum amount of pipe.

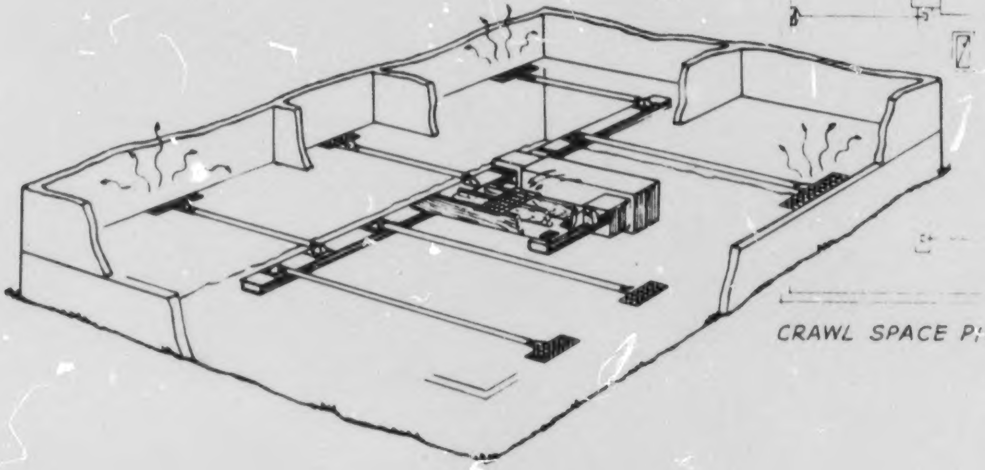


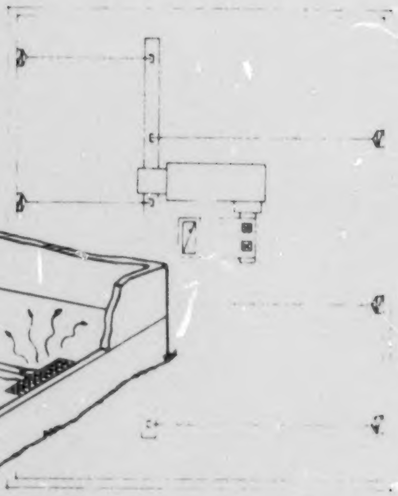
BASEMENT PIPING PLAN FIRST FLOOR PLAN

FIGURE 4.2

HORIZONTAL FURNACE SYSTEM

In some cases, where there is sufficient height, a horizontal oil or gas furnace is suspended from joists in crawl space. Extended plenum or radial type supply distribution piping may be used. Plenum, ducts and pipes should be insulated.





CRAWL SPACE PIPING PLAN

FIGURE 4.4

EXTENDED PLENUM SYSTEM

Large crawl space houses that are rambling or "L" shaped, may require extended plenum ductwork with branch supply pipes to outlets. This especially must be considered where system is to include summer air conditioning.

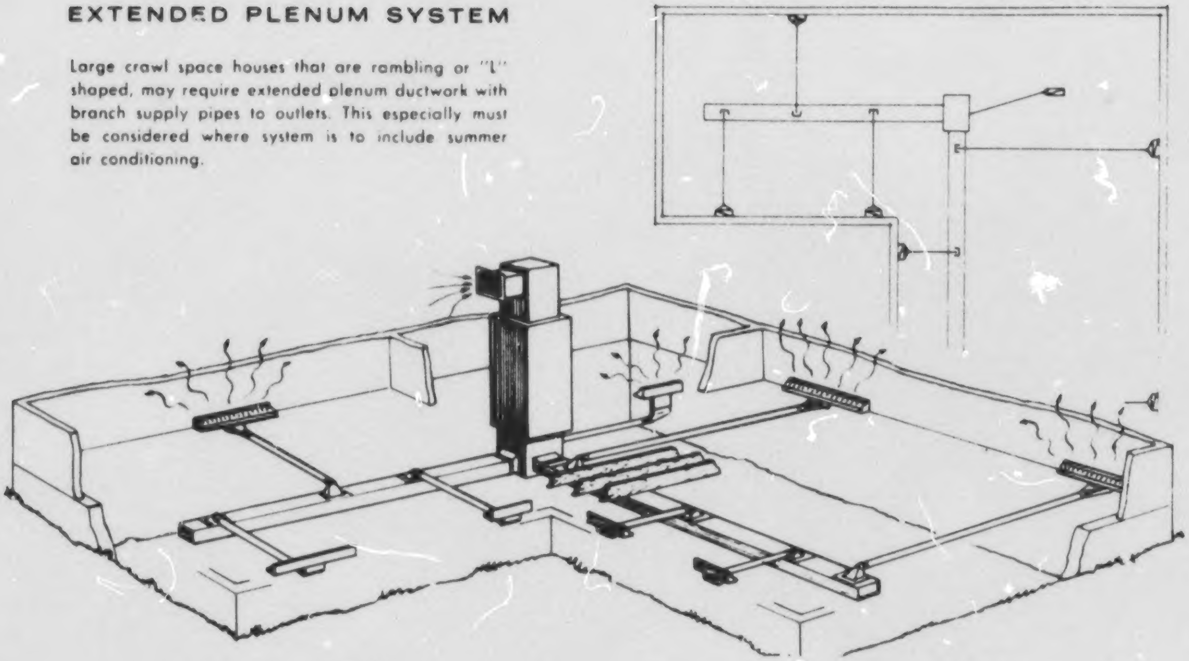
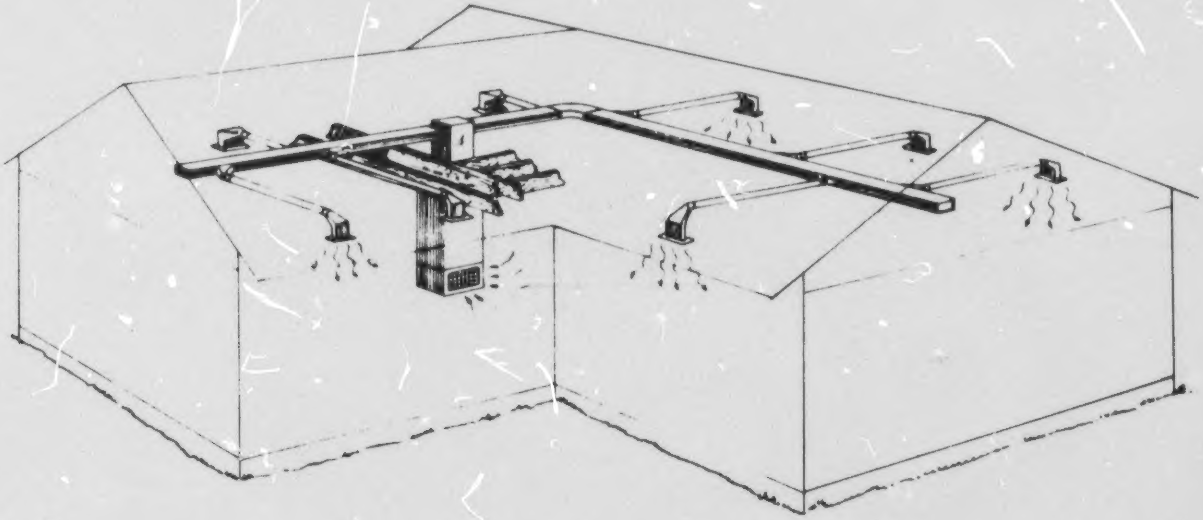
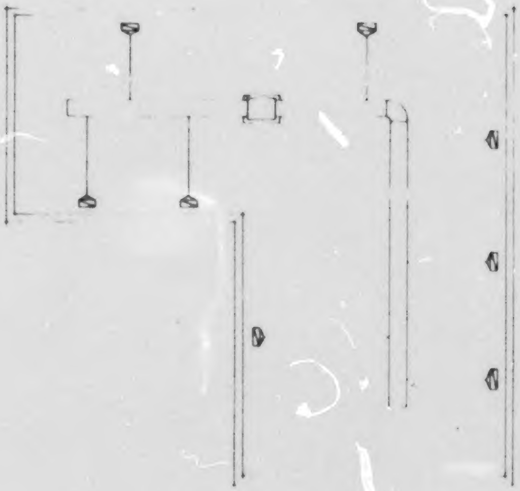


FIGURE 4.5

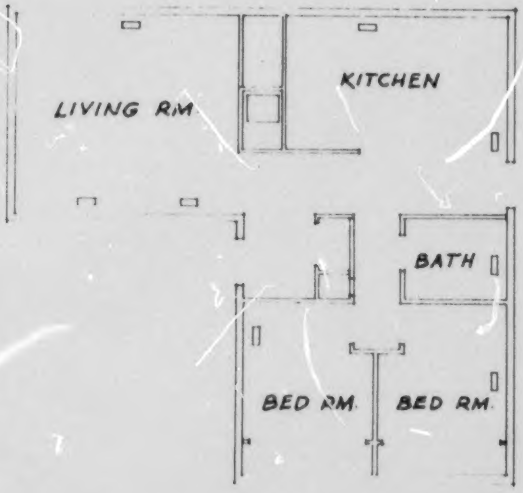
EXTENDED PLENUM IN ATTIC

Unless furnace plenum and supply pipes are cast in the concrete when slab is poured, piping for this type of house must run in the attic. Ducts and piping run across top of joists. Floor diffusers are turned upside down and installed in ceiling near outside walls. Round diffusers centered in room ceilings may be used. Plenum and piping must be insulated.





ATTIC PIPING PLAN

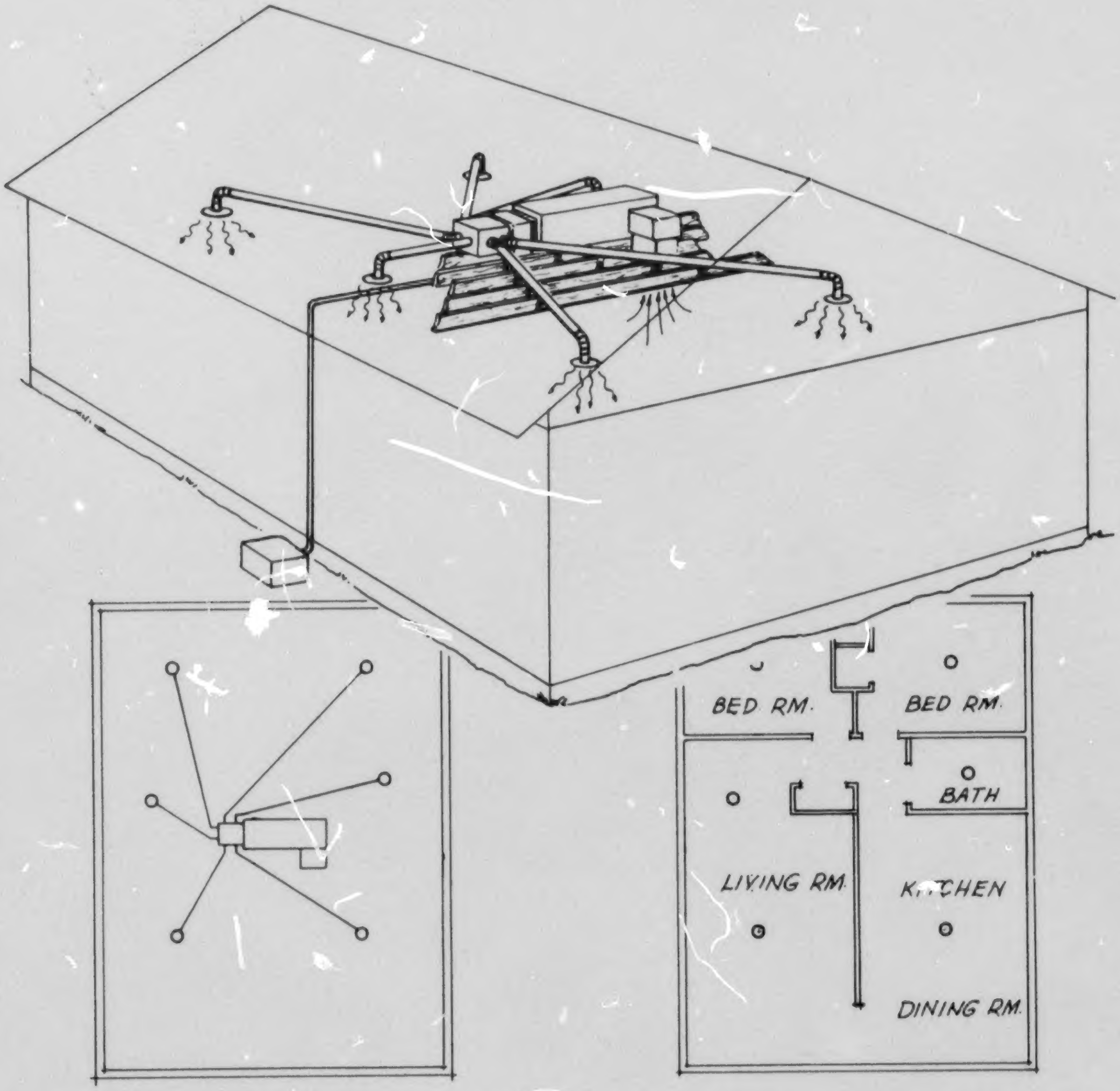


FIRST FLOOR PLAN

FIGURE 4.6

HORIZONTAL FURNACE IN ATTIC

In some installations, a gas horizontal furnace is installed in a properly ventilated attic. Little or no wall cutting is required; diffusers are installed in ceiling; return air grille in ceiling or high wall position. Also an excellent piping system for summer air conditioning. Use extended plenum or radial piping design. Plenums, ducts and pipes must be fully insulated.

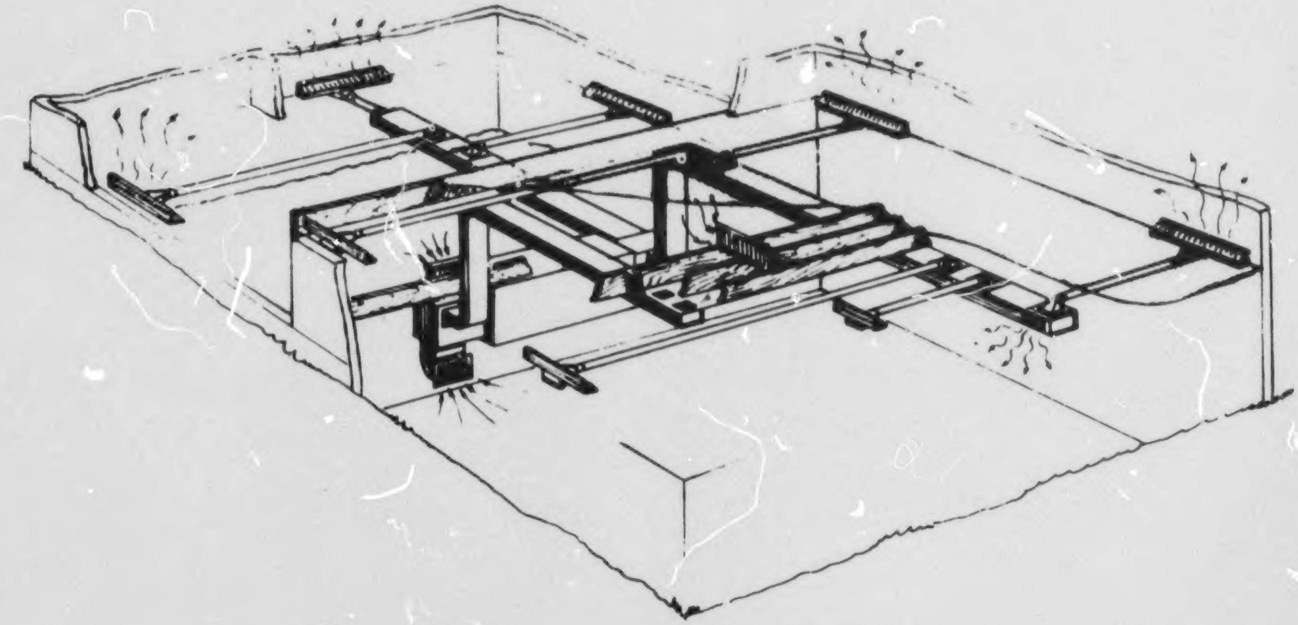


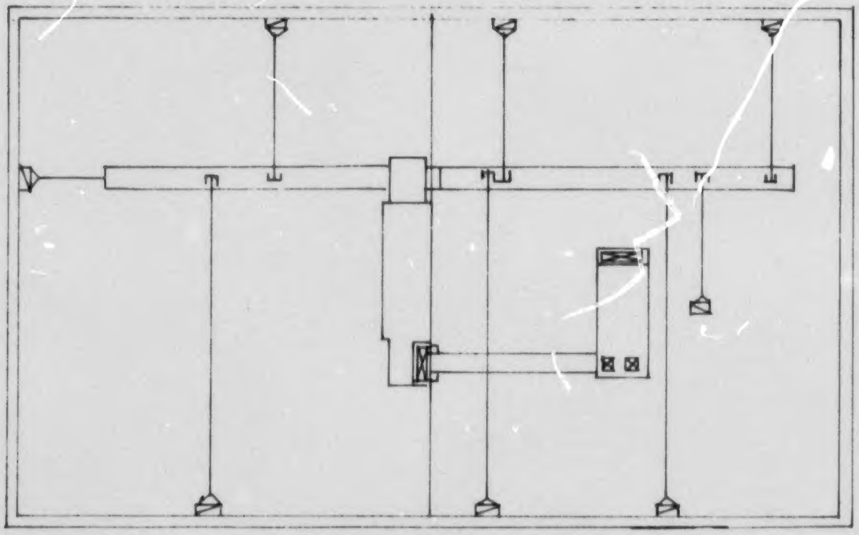
ATTIC PIPING PLAN

FIRST FLOOR PLAN

FIGURE 4.7

In the illustration shown **a horizontal furnace is suspended** from **joists** under second (ground) level. Ducts are run under floor joists of second and third levels. Branch supply pipes take off from top of ducts and run in joist spaces to baseboard diffusers. A register near end of the supply duct furnishes heat to the first level. Return air grilles are used at each level.





BASEMENT PIPING PLAN

FIGURE 4.8

A basement lowboy furnace with an upflow cooling coil and outside condenser unit provide year around air conditioning for house shown. Conditioned air is distributed to first floor rooms through baseboard diffusers; second floor rooms are supplied by wall stacks extending through interior and connected to registers. A baseboard grille in downstairs hall and a high-wall grille in second floor collect return air, which drops into sheeted joist spaces.

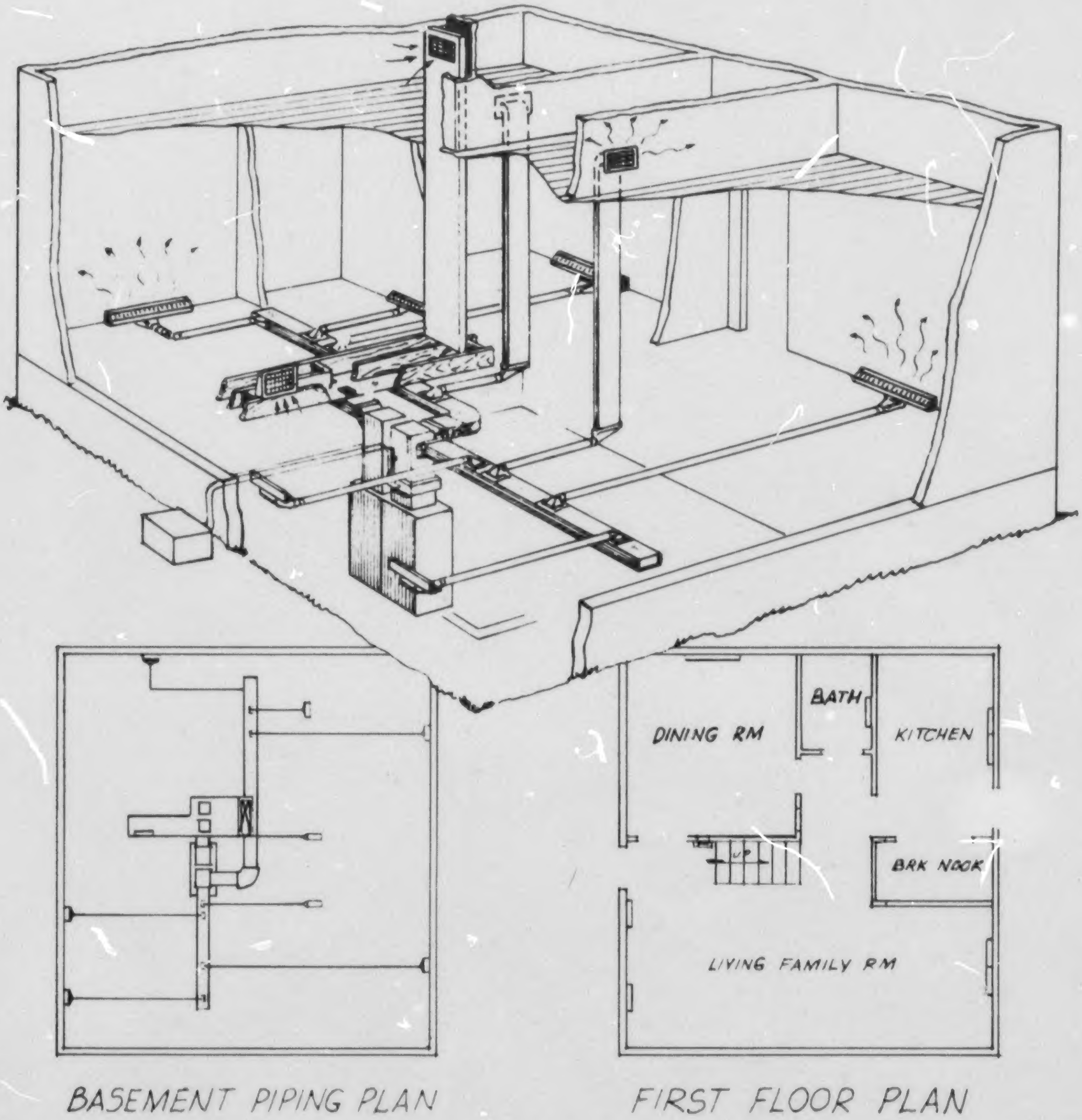
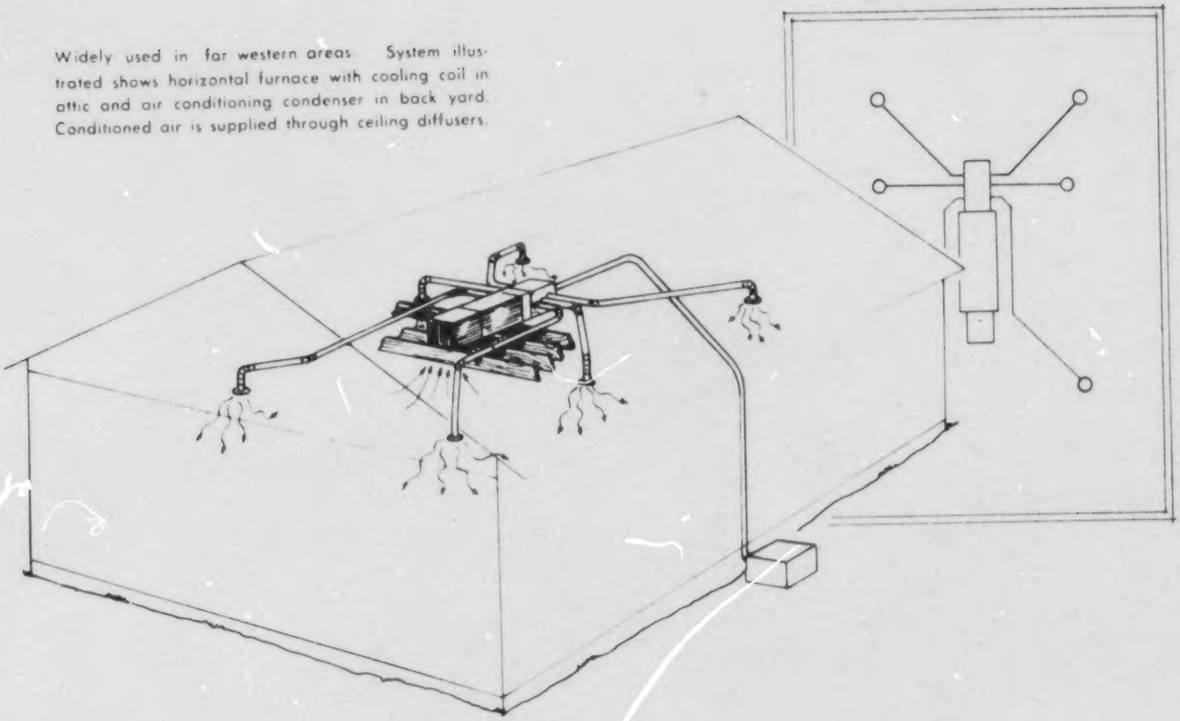

DINING RM
BATH
KITCHEN
UP
BRK NOOK
LIVING FAMILY RM
BASEMENT PIPING PLAN
FIRST FLOOR PLAN

FIGURE 4.9



Widely used in far western areas. System illustrated shows horizontal furnace with cooling coil in attic and air conditioning condenser in back yard. Conditioned air is supplied through ceiling diffusers.

FIGURE 4.10

In the milder climates of the southwest, a dropped ceiling in a central hallway is often used as a main distribution duct. Registers are installed in walls of rooms adjoining the hallway to supply conditioned air. The furnace is installed in a hall utility closet and is mounted on the floor or return air plenum. A grille in baseboard acts as the return air intake.

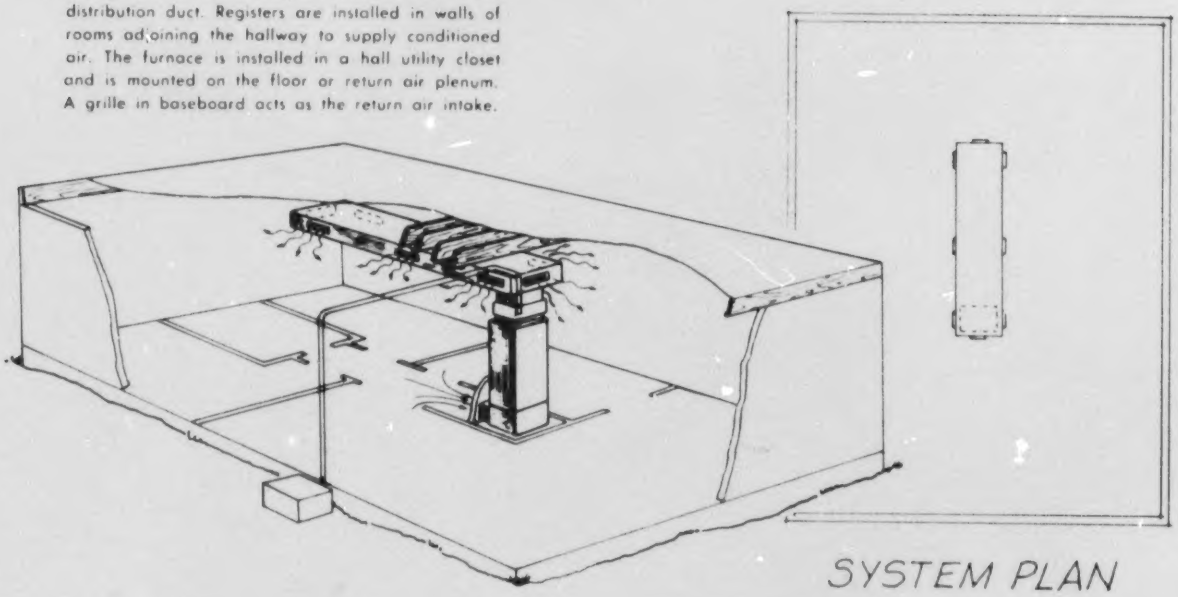


FIGURE 4.11

D. INSULATION OF DUCTS

The ducts used to heat and air condition a home can be a major source of energy loss. In the winter, heat energy is lost from the ducts into cooler, unheated spaces; in the summer, heat energy is absorbed by the air conditioning ducts passing through noninsulated spaces. Air conditioning ducts are also susceptible to water condensation, and this can rust out a duct system in just a few years.

In heating systems, a duct running through any unheated area, such as an attic, garage, or unheated crawl space, should be insulated to reduce heat loss. While special ductwrapping insulations are available for this purpose, you might find it more economical to use regular batting insulation. Normally, two inches or more of insulation is needed to adequately insulate heating ducts. The insulation should have a protective covering or backing; although a vapor barrier is usually not required over the outside of the insulation if the duct is used only for heating. If the heating ducts run through an insulated crawl space, the ducts will not usually require insulation. In the winter, the crawl space should be sealed off, so the temperature in the area will be high enough to prevent much heat loss through the exposed ducts.

Many new types of duct material are available. One type consists of fiberglass sheets that can be folded into a rectangle and taped in shape. The ends of each section are then notched and the pieces fitted together (like two pieces of pipe) and the seams are then taped to prevent air leakage. This fiberglass is manufactured with a vapor barrier covering (usually silver in color).

When air conditionig ducts run through any area that is not temperature-controlled, the ducts must be insulated and covered with a vapor barrier. Exposed air conditioning ducts not only increase your cooling load, they also cause the warm surrounding air to condense water vapor on the ducts, and this encourages rusting and other moisture problems. During the cooling season, the crawl space is generally cool enough that no moisture will condense on the ducts. If there is a condensation problem, a simple solution is to cut an outlet in the duct system to blow some cool air into the crawl space. This method normally results in an insignificant increase in cooling load because the crawl space is sealed, insulated and fairly cool to begin with. Just install a vent in the duct outlet in order to regulate the amount of cool air that enters the crawl space, and be sure to close the vent during the winter heating season.

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

POSTTEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. The energy efficiency ratio (EER) means very little when comparing the efficiencies of various air conditioners.

   a. true b. false

2. A Btu is the amount of heat required to raise the temperature of one pound of water by 10 degrees Fahrenheit.

   a. true b. false

3. 15.7 percent of the total U.S. energy budget is devoted to heating and cooling.

   a. true b. false

4. Examples of renewable energy sources include coal, gas, and oil.

   a. true b. false

5. Cool air speeds up evaporation.

   a. true b. false

6. The heating and cooling loads for a home will, obviously, not be the same.

   a. true b. false

7. The summer design temperature tells how many days the temperature, during the summer, will be over 95°F.

   a. true b. false

8. The output capacity of heating equipment should not exceed the calculated heat load by more than 15 percent.

   a. true b. false

9. It is impossible to determine the efficiency of a heating system.

   a. true b. false

10. It is possible for it to get too cold for a heat pump to work.

    a. true b. false

11. In the operation of electric furnaces, most of the heat loss occurs through a flue.

    a. true b. false

12. Dirty air filters affect the efficiency of a forced-air furnace.

    a. true b. false

13. Not all forced-air furnaces require filters.

    a. true b. false

14. It is true that electric baseboards have an efficiency approaching 100 percent.

    a. true b. false

15. One advantage of an electric heating system over a natural gas heating system is that the electric heating system does not require a flue.

    a. true b. false

16. In all cases, the condenser of an air conditioning system should be sheltered from natural wind currents.

    a. true b. false

17. Unlike warm air, cool air will not circulate by itself.

    a. true b. false

18. The fact that an air conditioner unit is too little is one of the biggest reasons that an air conditioning system does not perform to expectations.

    a. true b. false

19. In regard to space heaters, electric heaters should be considered first because they use very little energy.

    a. true b. false

20. During the winter, a realtive humidity of more than 70 percent makes the air feel dry.

    a. true b. false

MODULE X

HEATING, VENTILATING, AND AIR CONDITIONING CONSERVATION OPPORTUNITIES

ANSWERS TO POSTTEST

1. b. false
2. b. false
3. a. true
4. b. false
5. b. false
6. a. true
7. b. false
8. a. true
9. b. false
10. a. true
11. b. false
12. a. true
13. b. false
14. a. true
15. a. true
16. b. false
17. a. true
18. a. true
19. b. false
20. b. false

FIGURE 1.1

ENERGY USE
PERCENT OF TOTAL U.S. ENERGY USE IN RESIDENTIAL SECTOR

WOOD	NIL
COAL	NIL
NATURAL GAS	7.3%
ELECTRICITY	7.5%
OIL	4.4%
TOTAL	19.2%

SPACE HEATING	11.0%	15.7%
WATER HEATING	2.9%	
AIR CONDITIONING	0.7%	
REFRIGERATION	1.1%	
COOKING	1.1%	
LIGHTING	0.7%	
OTHER (SMALL APPLIANCES)	1.7%	
TOTAL	19.2%	

A

DESIGN TEMPERATURES FOR HEATING

The following table lists the outdoor winter temperatures in common use in these areas. These are recommended for use as the basis for preparing heating estimates.

State & City	Design Temp °F
ALABAMA	
Anniston	10
Birmingham	10
Gadsden	10
Mobile	20
Montgomery	20
Tuscaloosa	10
ALASKA	
Anchorage	-24
Barrow	-48
Bethel	-43
Cordova	-13
Fairbanks	-57
Juneau	-5
Ketchikan	4
Kodiak	4
Kotzebue	-46
Nome	-36
Seward	-4
Sitka	2
ARIZONA	
Bisbee	30
Flagstaff	-5
Globe	30
Nogales	30
Phoenix	35
Tucson	30
Winslow	-5
Yuma	40
ARKANSAS	
Bentonville	0
Fort Smith	5
Hot Springs	10
Little Rock	10
Pine Bluff	10
Texarkana	10
CALIFORNIA	
Bakersfield	30
El Centro	35
Eureka	30
Fresno	30
Long Beach	35
Los Angeles	40
Montague	15
Needles	25
Oakland	30
Pasadena	40
Red Bluff	15
Sacremento	30
San Bernardino	30
San Diego	45
San Francisco	35
San Jose	40
COLORADO	
Boulder	-15
Colorado Springs	-10
Denver	-10
Durango	-5
Fort Collins	-15
Grand Junction	-5
Leadville	-10
Pueblo	-15
CONNECTICUT	
Bridgeport	0
Hartford	0
New Haven	0
New London	5
Norwalk	0
Torrington	0
Waterbury	0
DELAWARE	
Dover	10
Milford	10
Wilmington	5
DIST. OF COLUMBIA	
Washington	10
FLORIDA	
Apalachicola	25
Fort Myers	40
Gainesville	30
Jacksonville	30
Key West	55
Miami	45
Orlando	35
Pensacola	25
Tallahassee	25
Tampa	35
GEORGIA	
Athens	10
Atlanta	10
Augusta	20
Brunswick	25
Columbus	20
Macon	20
Rome	10
Savannah	25
Way Cross	25
IDAHO	
Boise	-10
Idaho Falls	-15
Lewiston	10
Pocatello	-15
Twin Falls	-15
ILLINOIS	
Aurora	-10
Bloomington	-10
Cairo	0
Champaign	-10
Chicago	-10
Danville	-10
Decatur	-10
Elgin	-15
Joliet	-10
Moline	-10
Peoria	-15
Rockford	-15
Rock Island	-10
Springfield	-10
Urbana	-10
INDIANA	
Elkhart	-10
Evansville	-5
Fort Wayne	-5
Indianapolis	10
Lafayette	-10
South Bend	-10
Terre Haute	-5
IOWA	
Burlington	10
Cedar Rapids	-15
Charles City	-20
Clinton	-15
Council Bluffs	-15
Davenport	-10
Des Moines	15
Dubuque	-15
Fort Dodge	-15
Keokuk	-15
Marshalltown	-15
Sioux City	-15
Waterloo	15
KANSAS	
Atchison	10
Concordia	-10
Dodge City	10
Iola	5
Leavenworth	-10
Salina	-10
Topeka	-10
Wichita	5
KENTUCKY	
Bowling Green	0
Frankfort	0
Hopkinsville	0
Lexington	0
Louisville	0
Owensboro	0
Shelbyville	0
LOUISIANA	
Alexandria	20
Baton Rouge	20
New Orleans	25
Shreveport	15
MAINE	
Augusta	-15
Bangor	-20
Bar Harbor	-10
Belfast	-10
Eastport	-10
Lewiston	-10
Millinocket	-15
Orono	-20
Portland	-10
Presque Isle	-20
Rumford	-15
MARYLAND	
Annapolis	10
Baltimore	10
Cambridge	10
Cumberland	0
Frederick	5
Frostburg	-5
Salisbury	10
MASSACHUSETTS	
Amherst	-5
Boston	0
Fall River	0
Fitchburg	-5
Framingham	-5
Lawrence	-5
Lowell	-5
Nantucket	0
New Bedford	0
Pittsfield	-10
Plymouth	0
Springfield	-5
Worcester	-5
MICHIGAN	
Alpena	-10
Ann Arbor	-5
Big Rapids	-5
Cadillac	-10
Calumet	-20
Detroit	-5
Escanaba	20
Flint	-10
Grand Haven	-5
Grand Rapids	-5
Houghton	-20
Kalamazoo	-5
Lansing	10
Ludington	-5
Marquette	-15
Muskegon	5
Port Huron	-10
Saginaw	10
Sault Ste. Marie	20
MINNESOTA	
Alexandria	-25
Duluth	-25
Minneapolis	-25
Moorhead	-35
St. Cloud	-25
St. Paul	-25
MISSISSIPPI	
Biloxi	25
Columbus	10
Corinth	5
Hattiesburg	20
Jackson	15
Meridian	15
Natchez	15
Vicksburg	15
MISSOURI	
Columbia	-10
Hannibal	-10
Kansas City	-10
Kirksville	-10
St. Joseph	-10
St. Louis	-5
Springfield	-5
MONTANA	
Anaconda	-30
Billings	-30
Butte	-30
Great Falls	-40
Havre	-40
Helena	-40
Kalispell	-30
Miles City	-35
Missoula	-30
NEBRASKA	
Grand Island	-15
Hastings	-15
Lincoln	-15
Norfolk	-15
North Platte	-15
Omaha	-15
Valentine	-20
York	-15
NEVADA	
Elko	-10
Las Vegas	10
Reno	5
Tonopah	5
Winnemucca	-10
NEW HAMPSHIRE	
Berlin	-15
Claremont	-15
Concord	-10
Franklin	-15
Hanover	-15
Keene	-10
Manchester	-10
Nashua	-10
Portsmouth	-5
NEW JERSEY	
Asbury Park	5
Atlantic City	10
Bayonne	0
Belvidere	0
Bloomfield	0
Bridgeton	5
Camden	5
East Orange	0
Elizabeth	0
Jersey City	0
Newark	0
New Brunswick	5
Paterson	0
Phillipsburg	0
Trenton	0
NEW MEXICO	
Albuquerque	10
El Morro	0
Raton	-5
Roswell	5
Santa Fe	5
Tucumcari	5
NEW YORK	
Albany	-10
Auburn	-10
Binghamton	-5
Buffalo	-5
Canton	-20
Cortland	-10
Elmira	-5
Glens Falls	-15
Ithaca	5
Jamestown	-5
Lake Placid	-15
New York	5
Niagara Falls	5
Ogdensburg	20
Oneonta	10
Oswego	5
Port Jervis	0
Rochester	-5
Schenectady	10
Syracuse	-10
Watertown	-15
NORTH CAROLINA	
Asheville	5
Charlotte	15
Greensboro	10
Hatteras	20
New Bern	20
Raleigh	15
Salisbury	10
Wilmington	20
Winston-Salem	10
NORTH DAKOTA	
Bismarck	-30
Devils Lake	-30
Dickinson	-30
Fargo	-30
Grand Forks	-30
Jamestown	-30
Minot	-35
Pembina	-35
Williston	-35
OHIO	
Akron	-5
Cincinnati	-5
Cleveland	-5
Columbus	-5
Dayton	-5
Lima	-5
Marion	-5
Sandusky	-5
Toledo	-5
Warren	-5
Youngstown	-5
OKLAHOMA	
Ardmore	5
Bartlesville	-5
Guthrie	0
Muskogee	0
Oklahoma City	0
Tulsa	0
Waynoka	-5
OREGON	
Arlington	5
Baker	-15
Eugene	15
Medford	20
Pendleton	-10
Portland	10
Roseburg	20
Salem	15
Wamic	0
PENNSYLVANIA	
Altoona	-5
Bethlehem	0
Coatesville	5
Erie	-5
Harrisburg	5
New Castle	-5
Oil City	-5
Philadelphia	5
Pittsburgh	-5
Reading	5
Scranton	0
Warren	-5
Williamsport	-5
York	5
RHODE ISLAND	
Block Island	5
Bristol	0
Kingston	0
Pawtucket	0
Providence	0
SOUTH CAROLINA	
Charleston	20
Columbia	20
Florence	20
Greenville	10
Spartanburg	10
SOUTH DAKOTA	
Aberdeen	-25
Huron	-20
Pierre	-20
Rapid City	-20
Sioux Falls	-20
Watertown	-25
TENNESSEE	
Chattanooga	10
Jackson	5
Johnson City	0
Knoxville	5
Memphis	5
Nashville	5
TEXAS	
Abilene	5
Amarillo	0
Austin	15
Brownsville	30
Corpus Christi	25
Dallas	10
Del Rio	20
El Paso	20
Fort Worth	10
Galveston	25
Houston	20
Palestine	10
Port Arthur	20
San Antonio	20
Waco	10
UTAH	
Logan	-10
Milford	-5
Ogden	-5
Salt Lake City	0
VERMONT	
Bennington	-10
Burlington	-15
Montpelier	-20
Newport	-20
Northfield	-20
Rutland	-15
VIRGINIA	
Cape Henry	15
Charlottesville	10
Danville	10
Lynchburg	10
Norfolk	15
Petersburg	10
Richmond	10
Roanoke	5
Wytheville	5
WASHINGTON	
Aberdeen	20
Bellingham	10
Everett	15
North Head	20
Olympia	15
Seattle	15
Spokane	-15
Tacoma	15
Tatoosh Island	20
Walla Walla	-10
Wenatchee	-10
Yakima	-5
WEST VIRGINIA	
Bluefield	0
Charleston	0
Elkins	-5
Fairmont	0
Huntington	0
Martinsburg	0
Parkersburg	0
Wheeling	-5
WISCONSIN	
Ashland	-25
Beloit	-15
Eau Claire	-20
Green Bay	-20
La Crosse	-20
Madison	-20
Milwaukee	-15
Oshkosh	-20
Sheboygan	-20
WYOMING	
Casper	-25
Cheyenne	-20
Lander	-30
Sheridan	-30
Yellowstone Park	-35

FIGURE 1.2

X-125

DESIGN TEMPERATURES FOR AIR CONDITIONING

(OUTSIDE DRY- AND WET-BULB TEMPERATURES)

State & City	Summer DB	Summer WB
ALABAMA		
Anniston	95	78
Birmingham	95	78
Gadsden	95	78
Mobile	90	80
Montgomery	95	78
Tuscaloosa	95	78
ARIZONA		
Bisbee	100	72
Flagstaff	85	61
Globe	105	76
Nogales	105	72
Phoenix	105	76
Tucson	100	72
Winslow	95	65
Yuma	110	78
ARKANSAS		
Bentonville	95	76
Fort Smith	95	76
Hot Springs	95	78
Little Rock	95	78
Pine Bluff	95	78
Texarkana	100	78
CALIFORNIA		
Bakersfield	105	70
El Centro	110	78
Eureka	90	65
Fresno	105	74
Long Beach	90	70
Los Angeles	90	70
Montague	95	70
Needles	115	—
Oakland	80	65
Pasadena	95	70
Red Bluff	100	70
Sacramento	100	72
San Bernardino	105	72
San Diego	80	68
San Francisco	80	65
San Jose	90	70
COLORADO		
Boulder	95	64
Colorado Springs	95	65
Denver	95	64
Durango	95	65
Fort Collins	95	65
Grand Junction	95	65
Leadville	95	64
Pueblo	95	65
CONNECTICU'		
Bridgeport	85	75
Hartford	90	75
New Haven	85	75
New London	85	75
Norwalk	85	[illegible]
Torrington	90	75
Waterbury	90	75
DELAWARE		
Dover	90	78
Milford	90	78
Wilmington	90	78
DIST. OF COLUMBIA		
Washington	90	78
FLORIDA		
Apalachicola	95	80
Fort Myers	95	78
Gainesville	95	78
Jacksonville	95	78
Key West	100	78
Miami	90	79
Orlando	90	78
Pensacola	95	78
Tallahassee	95	78
Tampa	95	78
GEORGIA		
Athens	95	76
Atlanta	95	76
Augusta	100	76
Brunswick	95	78
Columbus	100	76
Macon	95	78
Rome	95	76
Savannah	95	78
Way Cross	95	78
IDAHO		
Boise	95	65
Idaho Falls	90	65
Lewiston	95	65
Pocatello	90	65
Twin Falls	95	65
ILLINOIS		
Aurora	95	75
Bloomington	95	76
Cairo	100	78
Champaign	95	77
Chicago	95	75
Danville	95	77
Decatur	95	77
Elgin	95	78
Joliet	95	76
Moline	95	76
Peoria	95	76
Rockford	96	78
Rock Island	95	76
Springfield	95	77
Urbana	95	77
INDIANA		
Elkhart	95	75
Evansville	95	78
Fort Wayne	95	75
Indianapolis	95	76
Lafayette	95	76
South Bend	95	75
Terre Haute	95	78
IOWA		
Burlington	95	78
Cedar Rapids	95	78
Charles City	95	75
Clinton	95	78
Council Bluffs	100	78
Davenport	95	78
Des Moines	95	78
Dubuque	95	78
Fort Dodge	95	78
Keokuk	95	78
Marshalltown	95	78
Sioux City	95	78
Waterloo	95	78
KANSAS		
Atchison	100	76
Concordia	95	78
Dodge City	95	78
Iola	100	75
Leavenworth	100	76
Salina	100	78
Topeka	100	78
Wichita	100	75
KENTUCKY		
Bowling Gree	95	78
Frankfort	95	78
Hopkinsville	95	78
Lexington	95	78
Louisville	95	78
Owensboro	95	78
Shelbyville	95	78
LOUISIANA		
Alexandria	95	78
Baton Rouge	95	80
New Orleans	95	80
Shreveport	95	78
MAINE		
Augusta	85	73
Bangor	85	73
Bar Harbor	85	73
Belfast	85	73
Eastport	85	70
Lewiston	85	73
Millinocket	85	73
Orono	85	70
Portland	85	73
Presque Isle	85	73
Rumford	85	73
MARYLAND		
Annapolis	90	78
Baltimore	90	78
Cambridge	90	78
Cumberland	90	75
Frederick	90	78
Frostburg	90	[illegible]
Salisbury	90	78
MASSACHUSETTS		
Amherst	90	75
Boston	85	74
Fall River	85	75
Fitchburg	90	75
Framingham	85	75
Lawrence	85	74
Lowell	85	74
Nantucket	85	75
New Bedford	85	75
Pittsfield	90	75
Plymouth	85	75
Springfield	90	75
Worcester	90	75
MICHIGAN		
Alpena	90	75
Ann Arbor	90	76
Big Rapids	90	75
Cadillac	90	75
Calumet	80	73
Detroit	90	75
Escanaba	85	74
Flint	90	75
Grand Haven	90	75
Grand Rapids	90	74
Houghton	80	73
Kalamazoo	90	75
Lansing	90	75
Ludington	90	75
Marquette	80	73
Muskegon	90	74
Port Huron	90	75
Saginaw	90	75
Sault Ste. Mari	80	71
MINNESOTA		
Alexandria	85	74
Duluth	80	71
Minneapolis	90	76
Moorhead	95	75
St. Cloud	90	76
St. Paul	90	75
MISSISSIPPI		
Biloxi	90	80
Columbus	95	78
Corinth	95	78
Hattiesburg	95	80
Jackson	95	78
Meridian	95	79
Natchez	95	78
Vicksburg	95	78
MISSOURI		
Columbia	100	78
Hannibal	95	77
Kansas City	100	76
Kirksville	95	78
St. Joseph	100	76
St. Louis	95	78
Springfield	100	77
MONTANA		
Anaconda	85	59
Billings	90	66
Butte	85	59
Great Falls	90	63
Havre	95	70
Helena	90	63
Kalispell	90	63
Miles City	95	69
Missoula	90	63
NEBRASKA		
Grand Island	100	75
Hastings	100	75
Lincoln	95	78
Norfolk	95	78
North Platte	100	73
Omaha	100	78
Valentine	95	78
York	95	78
NEVADA		
Elko	95	63
Las Vegas	110	71
Reno	95	65
Tonopah	90	63
Winnemucca	95	65
NEW HAMPSHIRE		
Berlin	85	73
Claremont	85	73
Concord	85	73
Franklin	85	73
Hanover	85	73
Keene	85	73
Manchester	85	74
Nashua	85	74
Portsmouth	85	74
NEW JERSEY		
Asbury Park	90	78
Atlantic City	90	78
Bayonne	90	75
Belvidere	90	75
Bloomfield	90	75
Bridgeton	90	78
Camden	90	78
East Orange	90	75
Elizabeth	90	75
Jersey City	90	75
Newark	90	76
New Brunswick	90	75
Paterson	90	75
Phillipsburg	90	75
Trenton	90	78
NEW MEXICO		
Albuquerque	95	65
El Morro	85	65
Raton	95	65
Roswell	100	71
Santa Fe	90	65
Tucumcari	95	70
NEW YORK		
Albany	90	74
Auburn	90	74
Binghamton	90	72
Buffalo	85	73
Canton	85	73
Cortland	90	74
Elmira	90	73
Glens Falls	90	73
Ithaca	90	73
Jamestown	90	74
Lake Placid	80	73
New York	90	76
Niagara Falls	85	73
Ogdensburg	85	73
Oneonta	90	73
Oswego	90	74
Port Jervis	90	75
Rochester	90	74
Schenectady	90	74
Syracuse	90	74
Watertown	85	73
NORTH CAROLINA		
Asheville	90	75
Charlotte	95	78
Greensboro	90	76
Hatteras	90	80
New Bern	95	78
Raleigh	95	78
Salisbury	90	78
Wilmington	90	81
Winston Salem	90	76
NORTH DAKOTA		
Bismarck	95	73
Devils Lake	90	70
Dickinson	95	70
Fargo	95	75
Grand Forks	90	72
Jamestown	95	73
Minot	90	71
Pembina	90	73
Williston	90	73
OHIO		
Akron	90	75
Cincinnati	95	78
Cleveland	90	75
Columbus	90	76
Dayton	90	76
Lima	90	75
Marion	90	75
Sandusky	90	75
Toledo	90	75
Warren	90	75
Youngstown	90	75
OKLAHOMA		
Ardmore	100	78
Bartlesville	100	77
Guthrie	100	77
Muskogee	95	79
Oklahoma City	100	77
Tulsa	100	77
Waynoka	105	75
OREGON		
Arlington	95	68
Baker	90	66
Eugene	90	68
Medford	95	68
Pendleton	90	66
Portland	85	68
Roseburg	90	66
Salem	90	68
Wamic	90	66
PENNSYLVANIA		
Altoona	90	75
Bethlehem	90	75
Coatesville	90	75
Erie	85	74
Harrisburg	90	75
New Castle	90	75
Oil City	90	75
Philadelphia	90	78
Pittsburgh	90	75
Reading	90	75
Scranton	90	75
Warren	90	75
Williamsport	90	74
York	90	75
RHODE ISLAND		
Block Island	85	75
Bristol	90	75
Kingston	85	75
Pawtucket	90	75
Providence	90	75
SOUTH CAROLINA		
Charleston	90	80
Columbia	95	78
Florence	95	79
Greenville	95	75
Spartanburg	95	78
SOUTH DAKOTA		
Aberdeen	95	75
Huron	100	75
Pierre	95	73
Rapid City	95	70
Sioux Falls	95	75
Watertown	95	73
TENNESSEE		
Chattanooga	95	76
Jackson	95	78
Johnson City	95	78
Knoxville	95	75
Memphis	95	78
Nashville	95	78
TEXAS		
Abilene	95	74
Amarillo	95	72
Austin	100	78
Brownsville	95	80
Corpus Christi	95	80
Dallas	100	78
Del Rio	100	78
El Paso	100	69
Fort Worth	100	78
Galveston	95	80
Houston	95	80
Palestine	100	78
Port Arthur	95	80
San Antonio	100	78
Waco	100	78
UTAH		
Logan	95	65
Milford	95	66
Ogden	90	65
Salt Lake City	95	65
VERMONT		
Bennington	90	73
Burlington	90	73
Montpelier	90	73
Newport	85	73
Northfield	90	73
Rutland	90	73
VIRGINIA		
Cape Henry	90	78
Charlottesville	90	78
Danville	90	78
Lynchburg	90	76
Norfolk	90	78
Petersburg	90	78
Richmond	90	78
Roanoke	90	76
Wytheville	90	76
WASHINGTON		
Aberdeen	85	64
Bellingham	80	65
Everett	80	65
North Head	80	65
Olympia	80	64
Seattle	80	65
Spokane	80	65
Tacoma	80	64
Tatoosh Island	80	65
Walla Walla	90	65
Wenatchee	90	65
Yakima	90	67
WEST VIRGINIA		
Bluefield	95	75
Charleston	90	75
Elkins	90	74
Fairmont	90	75
Huntington	90	[illegible]
Martinsburg	90	75
Parkersburg	90	75
Wheeling	90	75
WISCONSIN		
Ashland	80	71
Beloit	[illegible]	78
Eau Claire	90	[illegible]
Green Bay	90	74
La Crosse	95	75
Madison	90	75
Milwaukee	90	75
Oshkosh	90	75
Sheboygan	90	75
WYOMING		
Casper	90	62
Cheyenne	90	62
Lander	90	63
Sheridan	90	65
Yellowstone Park	85	62

FIGURE 1.3

HEATING SYSTEM

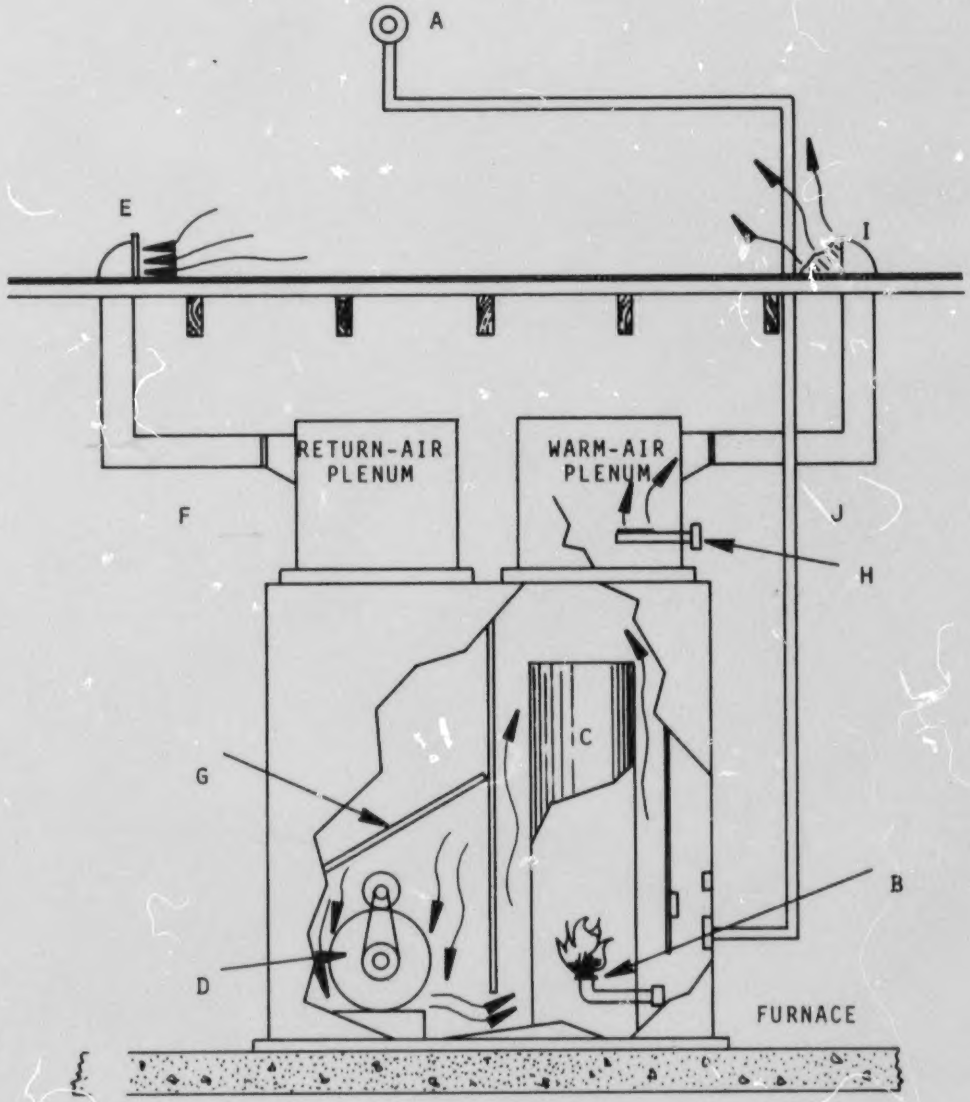

A
E
I
RETURN-AIR PLENUM
WARM-AIR PLENUM
F
J
H
C
G
B
D
FURNACE

FIGURE 2.1

DESIGN TEMPERATURES FOR HEATING

STATE AND CITY	DESIGN TEMP. ° F
TEXAS	5°
ABILENE	0°
AMARILLO	15°
BROWNSVILLE	30°
CORPUS CHRISTI	25°
DALLAS	10°
DEL RIO	20°
EL PASO	20°
FORT WORTH	10°
GALVESTON	25°
HOUSTON	20°
PALESTINE	10°
PORT ARTHUR	20°
SAN ANTONIO	20°
WACO	10°

HEATING ESTIMATE WORK SHEET

TYPE OF HOUSE ______________ STORY

● ATTIC INSULATION ☐ YES ☐ NO
● WALL INSULATION ☐ YES ☐ NO
● STORM SASH ☐ YES ☐ NO

DESIGN TEMPERATURE
OUTSIDE __________ °F
INSIDE __________ °F
DIFFERENCE __________ °F

TYPE OF EXPOSURE		GROSS AREA IN SQUARE FEET	×	MULTIPLIER	=	HEAT LOSS IN BTU'S
EXPOSED WALLS		PERIMETER × CEILING HT. = SQ. FT. ______ × ______ =	×		=	
GLASS	NO. OF WINDOWS	______ × 15 =				
	NO. OF DOORS	______ × 20 = ______				
	TOTAL GLASS		×		=	
COLD CEILING		LENGTH × WIDTH = SQ. FT.	×		=	
COLD FLOOR		______ × ______ =	×		=	

TOTAL HEAT LOSS IN BTU'S NEEDED AT REGISTER OR RADIATOR ➧ ☐

MULTIPLIERS

TYPE OF CONSTRUCTION		MULTIPLIERS FOR 70° AT OUTSIDE DESIGN TEMPERATURE						
		−30	−20	−10	0	+10	+20	+30
WALLS	FRAME OR BRICK VENEER STANDARD WALL							
	NO INSULATION	26	24	21	18	15	13	10
	WITH 2" OR MORE INSULATION	13	12	11	9	8	6	5
WINDOWS DOORS	PLAIN SINGLE GLASS	170	150	130	120	105	85	65
	WITH STORM SASH	80	70	60	55	50	40	30
CEILINGS	ATTIC ABOVE—NO INSULATION	32	29	25	22	19	15	12
	ATTIC ABOVE—3½" INSULATION	10	9	8	7	6	5	4
FLOORS	OVER BASEMENT (with furnace)	0	0	0	0	0	0	0
	OVER ENCLOSED CRAWL SPACE—4" INSULATION	5	5	[illegible]	4	3	3	2
	OVER ENCLOSED CRAWL SPACE—NO INSULATION	14	13	11	10	9	7	6
	OVER UNENCLOSED CRAWL SPACE	28	25	22	20	17	14	12
	ON A 4" CONCRETE SLAB	10	9	8	7	6	5	4

FIGURE 2.3

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HEATING ESTIMATE WORK SHEET

TYPE OF HOUSE ______ STORY

● ATTIC INSULATION ☐ YES ☐ NO
● WALL INSULATION ☐ YES ☐ NO
● STORM SASH ☐ YES ☐ NO

DESIGN TEMPERATURE
OUTSIDE ______ °F
INSIDE ______ °F
DIFFERENCE ______ °F

TYPE OF EXPOSURE		GROSS AREA IN SQUARE FEET	× MULTIPLIER	= HEAT LOSS IN BTU'S
EXPOSED WALLS		PERIMETER × CEILING HT. = SQ. FT. 148 × 8 = 1184	×	=
GLASS	NO. OF WINDOWS	10 × 15 = 150		
	NO. OF DOORS	2 × 20 = 40		
	TOTAL GLASS	190	× 130	= 24,700
COLD CEILING		LENGTH × WIDTH = SQ. FT. 46 × 28 = 1288	× 8	= 10,304
COLD FLOOR			× 0	= 0

TOTAL HEAT LOSS IN BTU'S NEEDED AT REGISTER OR RADIATOR ➧ 48,028

MULTIPLIERS

TYPE OF CONSTRUCTION		MULTIPLIERS FOR 70° AT OUTSIDE DESIGN TEMPERATURE						
		−30	−20	−10	0	+10	+20	+30
WALLS	FRAME OR BRICK VENEER STANDARD WALL							
	NO INSULATION	26	24	21	18	15	13	10
	WITH 2" OR MORE INSULATION	13	12	11	9	8	6	5
WINDOWS DOORS	PLAIN SINGLE GLASS	170	150	130	120	105	85	65
	WITH STORM SASH	80	70	60	55	50	40	30
CEILINGS	ATTIC ABOVE—NO INSULATION	32	29	25	22	19	15	12
	ATTIC ABOVE—3⅝" INSULATION	10	9	8	7	6	5	4
FLOORS	OVER BASEMENT (with furnace)	0	0	0	0	0	0	0
	OVER ENCLOSED CRAWL SPACE—4" INSULATION	5	5	4	4	3	3	2
	OVER ENCLOSED CRAWL SPACE—NO INSULATION	14	13	11	10	9	7	6
	OVER UNENCLOSED CRAWL SPACE	28	25	22	20	17	14	12
	ON A 4" CONCRETE SLAB	10	9	8	7	6	5	4

HOW TO USE WORK SHEET

There is only one "cold" ceiling — the one immediately below the attic. "Cold" floors are over an open area, on a concrete slab, or over an unexcavated area. Measure the length and width of these surfaces. When you have the measurements and other information filled in, figure the areas by multiplying the length times the width, as indicated on the work sheet.

Total area of exposed walls is the house perimeter (distance in feet around the outside) times ceiling height. For houses with more than one story, total the ceiling heights of all levels except basement, before multiplying by perimeter.

Multiply each of these areas by its indicated construction factor called a "multiplier" . . . to be found in the "MULTIPLIERS" Table on the work sheet. The answers will be in BTUs and will show the heat loss. Equipment is rated in BTUs, so if the total heat loss of the house is known, it is easy to pick a furnace or boiler of the proper size from the *Wards* Catalog.

DETERMINING THE HEAT LOSS FOR A SAMPLE HOUSE

The Type of House

In estimating the heat loss of a sample house *(page 17)*, information and calculations are entered on the Work Sheet as shown above. Here is where they come from . . .

This is a single story house with a full basement. Both the walls and the attic have insulation, but the doors and windows are not protected by storm sash. The design temperature is -10°.

FIGURE 2.4

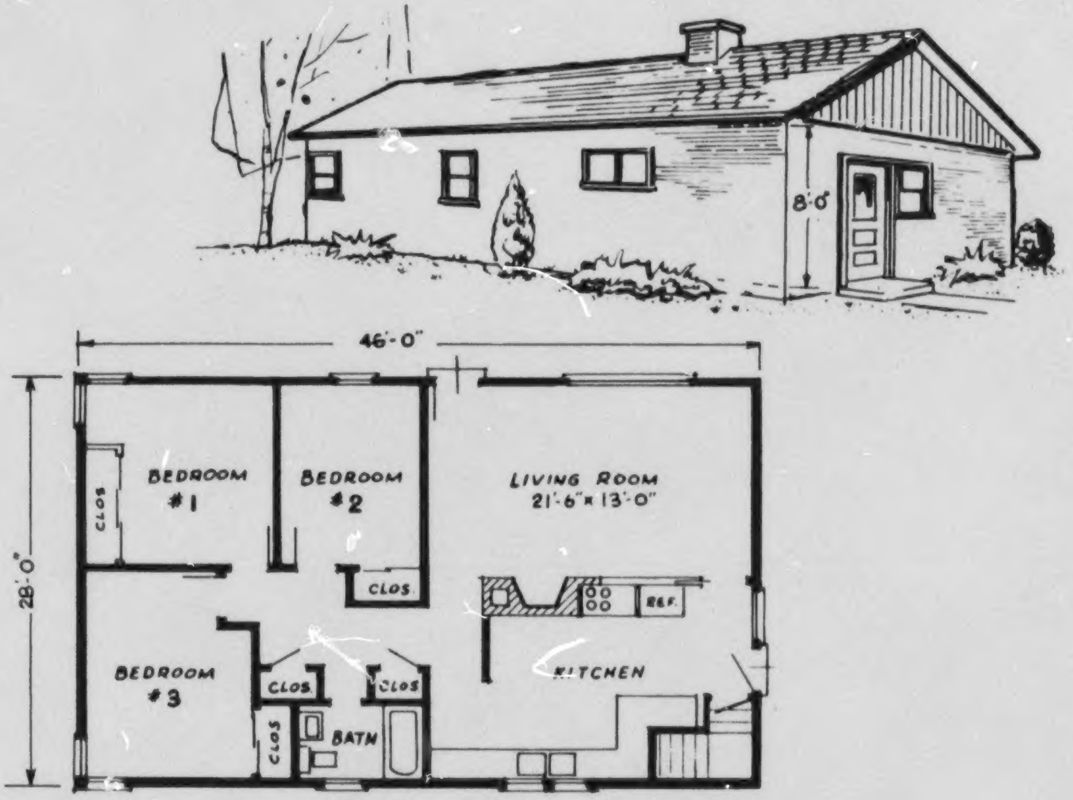


FIGURE 2.5

The Quick, Easy Calculations

WALLS Take the walls first. Walk around the house measuring its perimeter. In this example, it is 46 ft. *plus* 28 ft. *plus* 46 ft. *plus* 28 ft. or a total of 148 ft., which is entered on the form. Now, measure the ceiling height (8 ft). Multiplying these two figures (148 x 8) gives a total wall area of 1184 sq. ft.

Using the -10° column in the multiplier table, a figure of "11" is shown for insulated walls. Multiplying these figures (1184 x 11) gives a wall heat loss of 13,024 BTUs.

GLASS Count the number of windows (10) and multiply by "15." This gives a figure of 150 sq. ft. for windows. Similarly, count the number of doors (2) and multiply by "20" for a square foot figure of 40. Adding windows (150) and doors (40) gives a total glass area of 190. The multiplier for windows and doors without storm sash at -10° is "60". Multiplying these figures (190 x 130) gives the BTU heat loss of 24,700.

CEILING Ceiling area is the length of the house times its width (46 x 28) for a total of 1288 sq. ft. The multiplier for an insulated ceiling at -10° is "8." The heat loss of the ceiling then is (1288 x 8) or 10,304 BTUs.

FLOOR As the house has a full basement in which the furnace will be, the multiplier is "O". Therefore, the area of the floor need not be considered (since O x anything is still "O") . . . and the heat loss through the floor is nothing ("O").

TOTAL HEAT LOSS This is just the sum of the individual heat losses (13,024 plus 24,700 plus 10,304 plus 0) which is a total of 48,028 BTUs. This indicates the total amount of heat (in BTUs) that will be needed in the house. To obtain this amount of heat requires a furnace with an output rating (at the registers) of 48,028 BTUs, or more.

FIGURE 2.6

COMMON FUELS AND THEIR HEAT ENERGY PER UNIT

FUEL	UNIT	BTU PER UNIT
natural gas	cubic foot	1,000
	therm (100 cu ft)	100,000
propane	gallon	90,000
butane	gallon	130,000
No. 1 fuel oil	gallon	136,000
No. 2 fuel oil	gallon	140,000
electricity	kilowatt-hour	3,413

HEATING SYSTEM EFFICIENCY

HEAT SOURCE	EFFICIENCY
WOOD FURNACE OR STOVE	30-50%
COAL FURNACE	30-60%
NATURAL GAS FURNACE	75-80%
PROPANE FURNACE	75-80%
BUTANE FURNACE	75-80%
OIL FURNACE	75-80%
ELECTRIC FURNACE	90-100%
ELECTRIC BASEBOARD	95-100%

FIGURE 2.7

AIR CONDITIONING SYSTEM

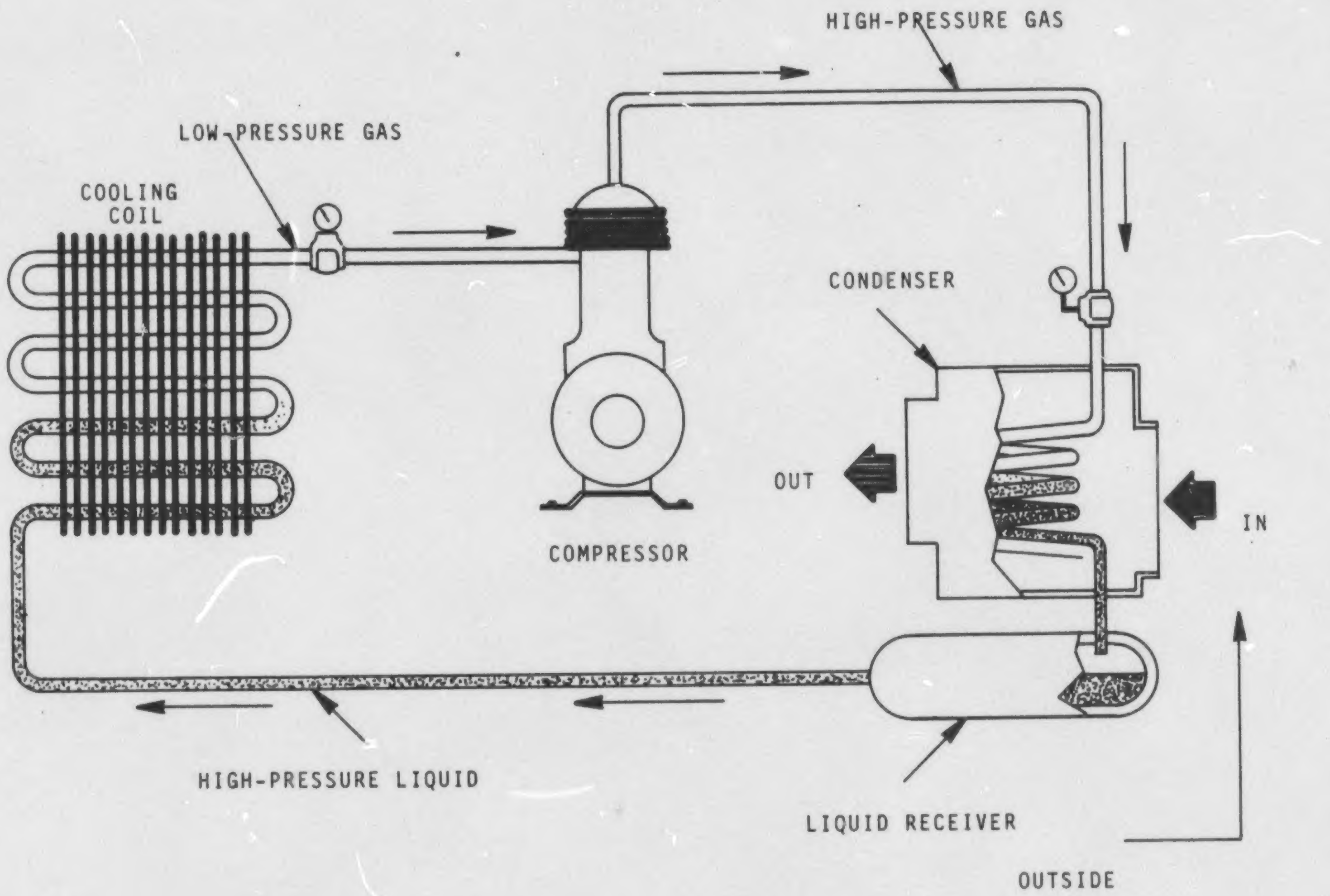

HIGH-PRESSURE GAS
LOW-PRESSURE GAS
COOLING COIL
CONDENSER
OUT
IN
COMPRESSOR
HIGH-PRESSURE LIQUID
LIQUID RECEIVER
OUTSIDE

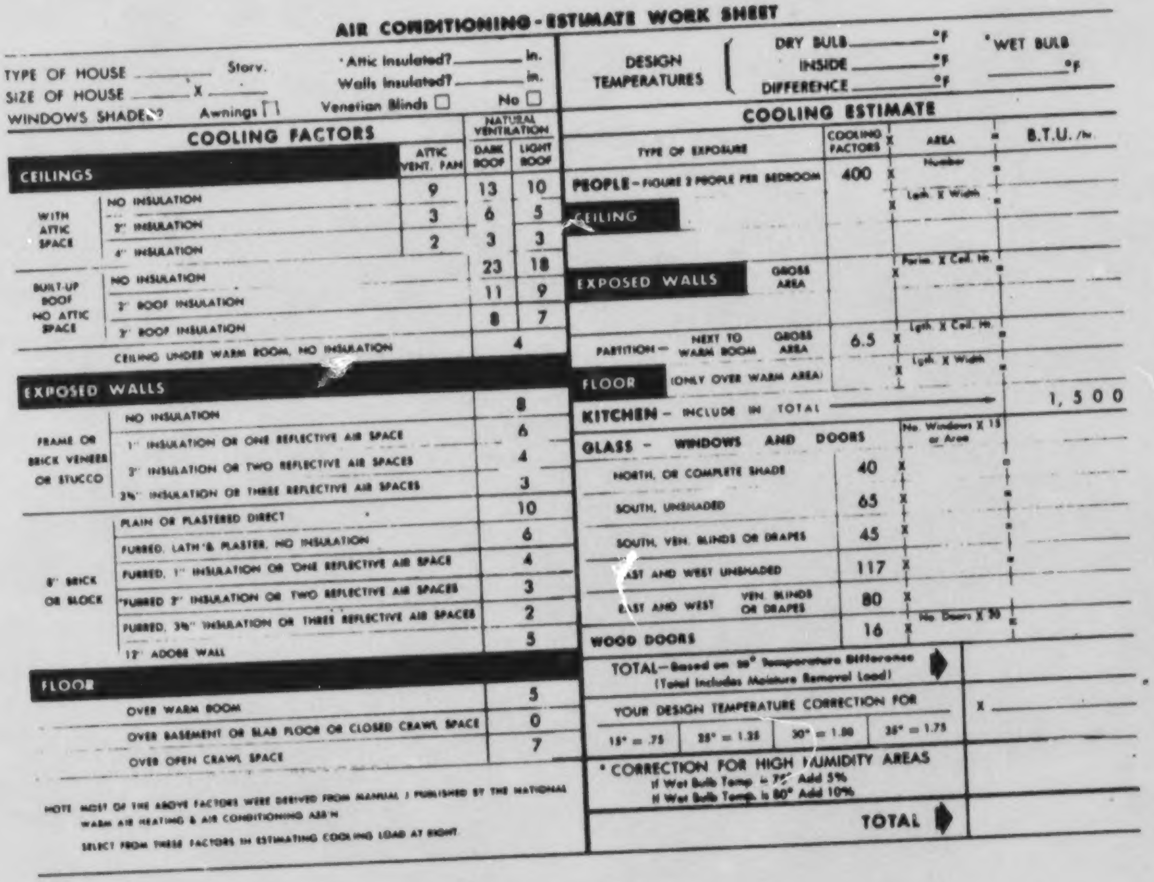
FIGURE 3.1

X-141

DESIGN TEMPERATURES FOR AIR CONDITIONING
(OUTSIDE DRY- AND WET-BULB TEMPERATURES)

STATE AND CITIES	SUMMER DB	SUMMER WB
TEXAS		
ABILENE	95	74
AMARILLO	95	72
AUSTIN	100	78
BROWNSVILLE	95	80
CORPUS CHRISTI	95	80
DALLAS	100	78
DEL RIO	100	78
EL PASO	100	69
FORT WORTH	100	78
GALVESTON	95	80
HOUSTON	95	80
PALESTINE	100	78
PORT ARTHUR	95	80
SAN ANTONIO	100	78
WACO	100	78

FIGURE 3.2



AIR CONDITIONING - ESTIMATE WORK SHEET

TYPE OF HOUSE ________ Story.
SIZE OF HOUSE ________ X ________
WINDOWS SHADED? Awnings ☐ Venetian Blinds ☐ No ☐
* Attic Insulated? ________ in.
Walls Insulated? ________ in.

DESIGN TEMPERATURES
DRY BULB ________ °F
INSIDE ________ °F
DIFFERENCE ________ °F
* WET BULB ________ °F

COOLING FACTORS

		NATURAL VENTILATION		
CEILINGS		ATTIC VENT. FAN	DARK ROOF	LIGHT ROOF
WITH ATTIC SPACE	NO INSULATION	9	13	10
	2" INSULATION	3	6	5
	4" INSULATION	2	3	3
BUILT-UP ROOF NO ATTIC SPACE	NO INSULATION		23	18
	2" ROOF INSULATION		11	9
	3" ROOF INSULATION		8	7
	CEILING UNDER WARM ROOM, NO INSULATION		4	
EXPOSED WALLS				
FRAME OR BRICK VENEER OR STUCCO	NO INSULATION		8	
	1" INSULATION OR ONE REFLECTIVE AIR SPACE		6	
	2" INSULATION OR TWO REFLECTIVE AIR SPACES		4	
	3⅝" INSULATION OR THREE REFLECTIVE AIR SPACES		3	
8" BRICK OR BLOCK	PLAIN OR PLASTERED DIRECT		10	
	FURRED, LATH & PLASTER, NO INSULATION		6	
	FURRED, 1" INSULATION OR ONE REFLECTIVE AIR SPACE		4	
	FURRED 2" INSULATION OR TWO REFLECTIVE AIR SPACES		3	
	FURRED, 3⅝" INSULATION OR THREE REFLECTIVE AIR SPACES		2	
	12" ADOBE WALL		5	
FLOOR				
	OVER WARM ROOM		5	
	OVER BASEMENT OR SLAB FLOOR OR CLOSED CRAWL SPACE		0	
	OVER OPEN CRAWL SPACE		7	

NOTE: MOST OF THE ABOVE FACTORS WERE DERIVED FROM MANUAL J PUBLISHED BY THE NATIONAL WARM AIR HEATING & AIR CONDITIONING ASS'N

SELECT FROM THESE FACTORS IN ESTIMATING COOLING LOAD AT RIGHT

COOLING ESTIMATE

TYPE OF EXPOSURE	COOLING FACTORS	X	AREA	=	B.T.U. /hr.
PEOPLE - FIGURE 2 PEOPLE PER BEDROOM	400	X	Number	=	
CEILING		X	Lgth. X Width	=	
EXPOSED WALLS GROSS AREA		X	Perim. X Ceil. Ht.	=	
PARTITION - NEXT TO WARM ROOM GROSS AREA	6.5	X	Lgth. X Ceil. Ht.	=	
FLOOR (ONLY OVER WARM AREA)		X	Lgth. X Width	=	
KITCHEN - INCLUDE IN TOTAL →					1, 5 0 0
GLASS - WINDOWS AND DOORS			No. Windows X 15 or Area		
NORTH, OR COMPLETE SHADE	40	X		=	
SOUTH, UNSHADED	65	X		=	
SOUTH, VEN. BLINDS OR DRAPES	45	X		=	
EAST AND WEST UNSHADED	117	X		=	
EAST AND WEST VEN. BLINDS OR DRAPES	80	X		=	
WOOD DOORS	16	X	No. Doors X 20	=	

TOTAL—Based on 20° Temperature Difference (Total Includes Moisture Removal Load) ➧	
YOUR DESIGN TEMPERATURE CORRECTION FOR 15° = .75 25° = 1.25 30° = 1.50 35° = 1.75	X ________
* CORRECTION FOR HIGH HUMIDITY AREAS If Wet Bulb Temp is 75° Add 5% If Wet Bulb Temp is 80° Add 10%	
TOTAL ➧	

FIGURE 3.3

AIR CONDITIONING-ESTIMATE WORK SHEET

TYPE OF HOUSE Two Story. Attic Insulated? 3 5/8 in.
SIZE OF HOUSE 25' x 28' Walls Insulated? 2 in.
WINDOWS SHADED? Awnings ☒ Venetian Blinds ☐ No ☐

DESIGN TEMPERATURES
DRY BULB 100 °F
INSIDE 75 °F
DIFFERENCE 25 °F
*WET BULB 78 °F

COOLING FACTORS

CEILINGS		ATTIC VENT. FAN	NATURAL VENTILATION DARK ROOF	NATURAL VENTILATION LIGHT ROOF
WITH ATTIC SPACE	NO INSULATION	9	13	10
	2" INSULATION	3	6	5
	4" INSULATION	2	[✓ 3]	3
BUILT-UP ROOF NO ATTIC SPACE	NO INSULATION		23	18
	2" ROOF INSULATION		11	9
	3" ROOF INSULATION		8	7
	CEILING UNDER WARM ROOM, NO INSULATION		4	
EXPOSED WALLS				
FRAME OR BRICK VENEER OR STUCCO	NO INSULATION		8	
	1" INSULATION OR ONE REFLECTIVE AIR SPACE		6	
	2" INSULATION OR TWO REFLECTIVE AIR SPACES		[✓ 4]	
	3⅝" INSULATION OR THREE REFLECTIVE AIR SPACES		3	
8" BRICK OR BLOCK	PLAIN OR PLASTERED DIRECT		10	
	FURRED, LATH & PLASTER, NO INSULATION		6	
	FURRED, 1" INSULATION OR ONE REFLECTIVE AIR SPACE		4	
	FURRED 2" INSULATION OR TWO REFLECTIVE AIR SPACES		3	
	FURRED, 3⅝" INSULATION OR THREE REFLECTIVE AIR SPACES		2	
	12" ADOBE WALL		5	
FLOOR				
	OVER WARM ROOM		5	
	OVER BASEMENT OR SLAB FLOOR OR CLOSED CRAWL SPACE		0	
	OVER OPEN CRAWL SPACE		7	

NOTE: MOST OF THE ABOVE FACTORS WERE DERIVED FROM MANUAL J PUBLISHED BY THE NATIONAL WARM AIR HEATING & AIR CONDITIONING ASS'N

SELECT FROM THESE FACTORS IN ESTIMATING COOLING LOAD AT RIGHT

COOLING ESTIMATE

TYPE OF EXPOSURE	COOLING FACTORS	× AREA	= B.T.U./hr.
PEOPLE – FIGURE 2 PEOPLE PER BEDROOM	400	Number 5	2000
CEILING	3	Lgth. X Width 28×25	2100
EXPOSED WALLS GROSS AREA	4	Perim. X Ceil. Ht. 106×16	6784
PARTITION – NEXT TO WARM ROOM GROSS AREA	6.5	Lgth. X Ceil. Ht.	
FLOOR (ONLY OVER WARM AREA)		Lgth. X Width	
KITCHEN – INCLUDE IN TOTAL →			1,500
GLASS – WINDOWS AND DOORS		No. Windows X 15 or Area	
NORTH, OR COMPLETE SHADE	40	17×15	10 200
SOUTH, UNSHADED	65		
SOUTH, VEN. BLINDS OR DRAPES	45		
EAST AND WEST UNSHADED	117		
EAST AND WEST VEN. BLINDS OR DRAPES	80		
WOOD DOORS	16	No. Doors X 20 2×20	640
TOTAL–Based on 20° Temperature Difference (Total Includes Moisture Removal Load)			23224
YOUR DESIGN TEMPERATURE CORRECTION FOR 15° = .75 | 25° = 1.25 | 30° = 1.50 | 35° = 1.75			× 1.25 29030
* CORRECTION FOR HIGH HUMIDITY AREAS If Wet Bulb Temp. is 78° Add 5% If Wet Bulb Temp. is 80° Add 10%			1451
TOTAL			30481

DETERMINING THE COOLING FOR A SAMPLE HOUSE

Enter your information and calculations on the Work Sheet as shown following:

PEOPLE This 3-bedroom home will normally house 5 people, which multiplied by the factor "400", gives a cooling load of 5 x 400 or 2000 BTU/Hr.

CEILING The area is length of house times width (28 x 25) or 700 sq. ft. The ceiling cooling factor for a dark color roof and attic space with between 2-in. and 4-in. insulation, is "3". The load then is 700 x 3 or 2100 BTU/Hr.

FIGURE 3.4

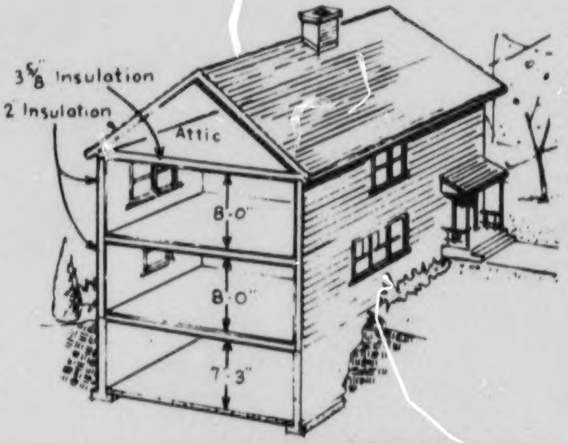
HOUSE SPECIFICATIONS

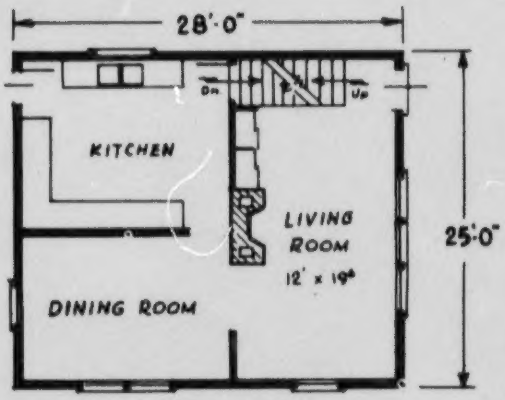
DESIGN TEMPERATURES

100° Dry Bult – 75° Inside = 25° Difference

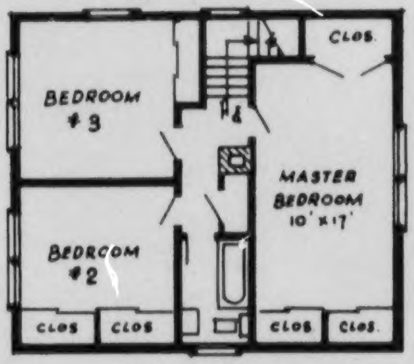
78° Wet Bulb Temp.

Roof	Dark Color
Walls	Frame With 2" Insulation
Ceiling	With Attic and 3-5/8" Insulation
Windows	All North or With Awnings
Basement	Under Entire House





FIRST FLOOR



SECOND FLOOR

EXPOSED WALLS Total area of exposed walls is perimeter of house times ceiling height (of upper ceiling). This is 106 (25+28+25+28) times 16 (2 stories) or 1,696 sq. ft. The cooling factor table shows frame walls with 2-in. insulation has the factor "4". Multiplying 1,696 sq. ft. by 4 gives a load of 6,784 BTU/Hr.

FLOOR Over basement . . . no factor required.

WINDOWS House has 17 windows, either facing north or completely shaded by awnings. This means that all windows will have a cooling factor of "40". First, multiply the 17 windows by "15" for glass area (17 x 15 = 255), then by 40 (255 x 40 = 10,200). This means that the cooling load for glass is 10,200 BTU/Hr.

WOOD DOORS The 2 wood doors to the outside are multiplied by "20" for area (2 x 20 = 40), then by the indicated factor "16" (40 x 16 = 640) for a load of 640 BTU/Hr.

KITCHEN A standard load of 1,500 BTU/Hr. is added for kitchen activities.

TOTAL COOLING LOAD (based on 20° temperature difference) This is the total of the preceding individual loads. In this example, it is 2,000 + 2,100 + 6,784 + 10,200 + 640 + 1,500 or 23,224 BTU/Hr.

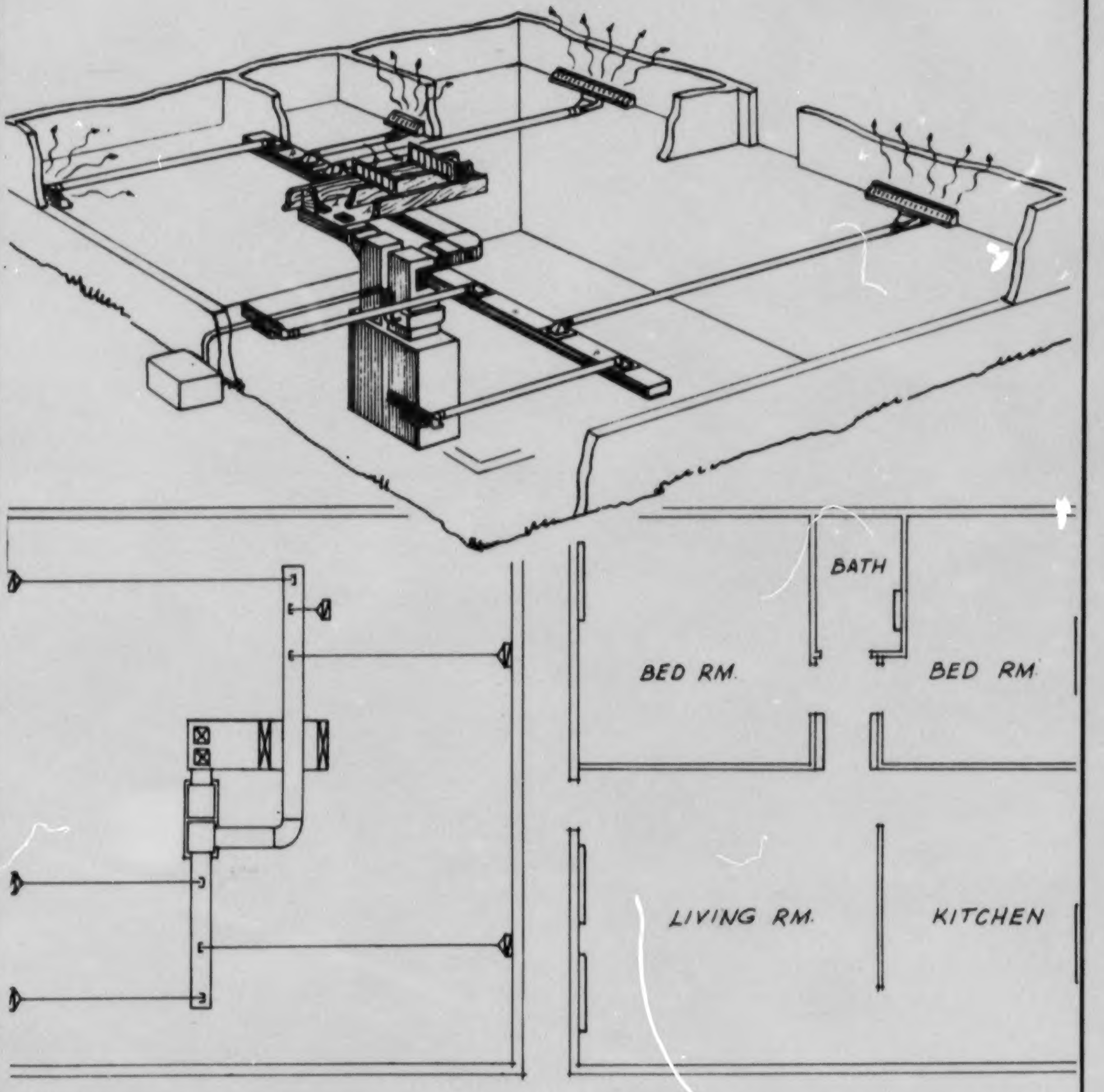
DESIGN TEMPERATURE CORRECTION An allowance must be made because the difference between the outside dry bulb temperature (100°) and the desired inside temperature (75°) is greater than 20°. The Work Sheet indicates that a difference of 25° (100° – 75°) requires a correction factor of 1.25. The adjusted cooling load (23,224 x 1.25) then becomes 29,030 BTU/Hr.

HIGH HUMIDITY CORRECTION This area has a wet bulb reading of 78°. The Work Sheet indicates that under such conditions, 5% must be added to the cooling load (29,030 x .05 = 1451; 29,030 + 1451 = 30,481). The final cooling load then becomes 30,481 BTU/Hr.

FIGURE 3.5

EXTENDED PLENUM SYSTEM

The extended plenum system usually is preferred for basement installation because of its neat appearance. Branch pipes to outlets may be round or rectangular and are run between or beneath basement joists. The extended plenum is usually required for larger installations.

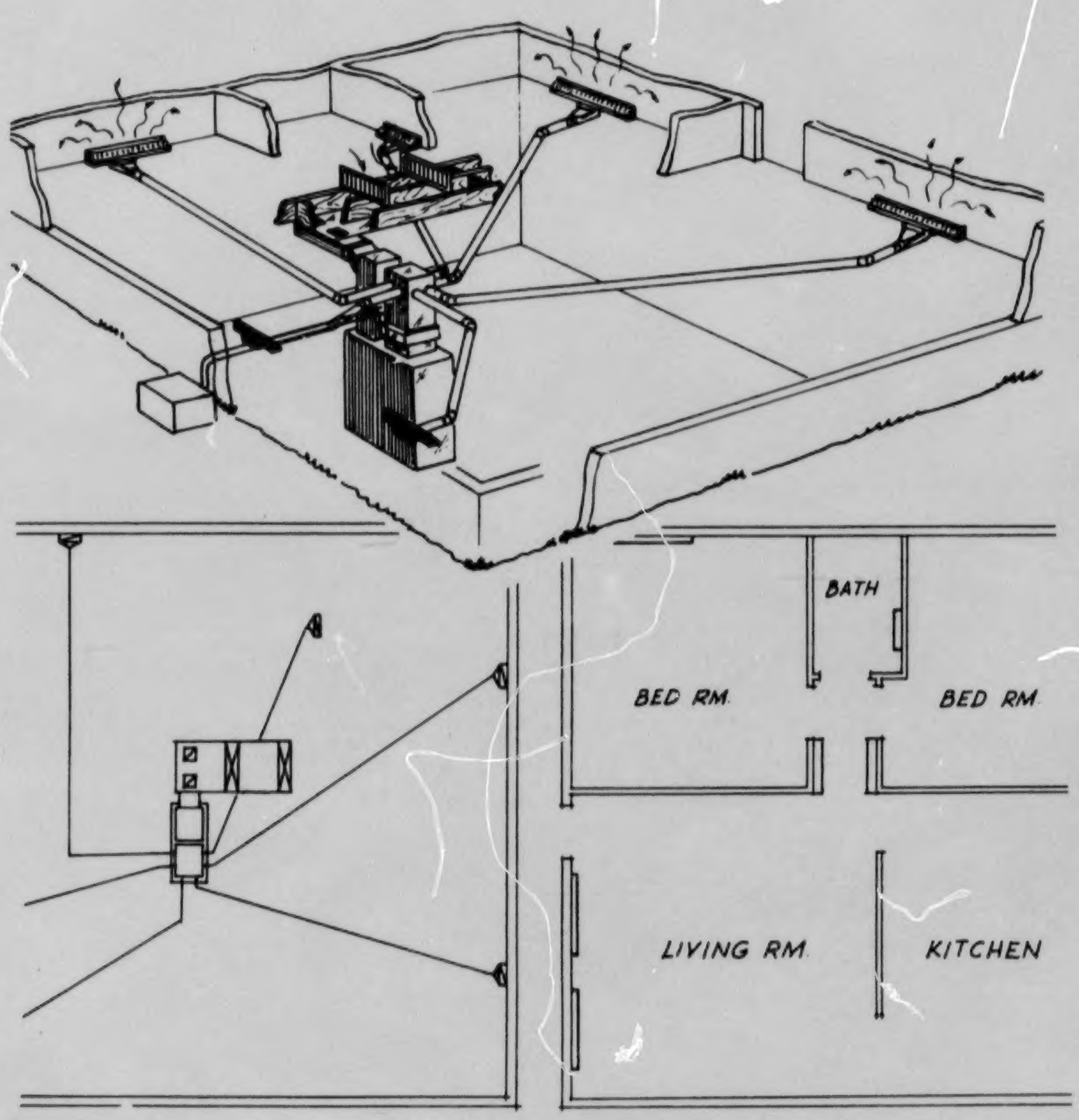


BASEMENT PIPING PLAN FIRST FLOOR PLAN

FIGURE 4.1

RADIAL PIPING SYSTEM

This method of piping can be used where length of individual pipe runs does not exceed limits of pipe capacity and where appearance is not a factor. Pipes are suspended from basement joists and run in as direct a line as possible from plenum to outlet connection. Requires a minimum amount of pipe.

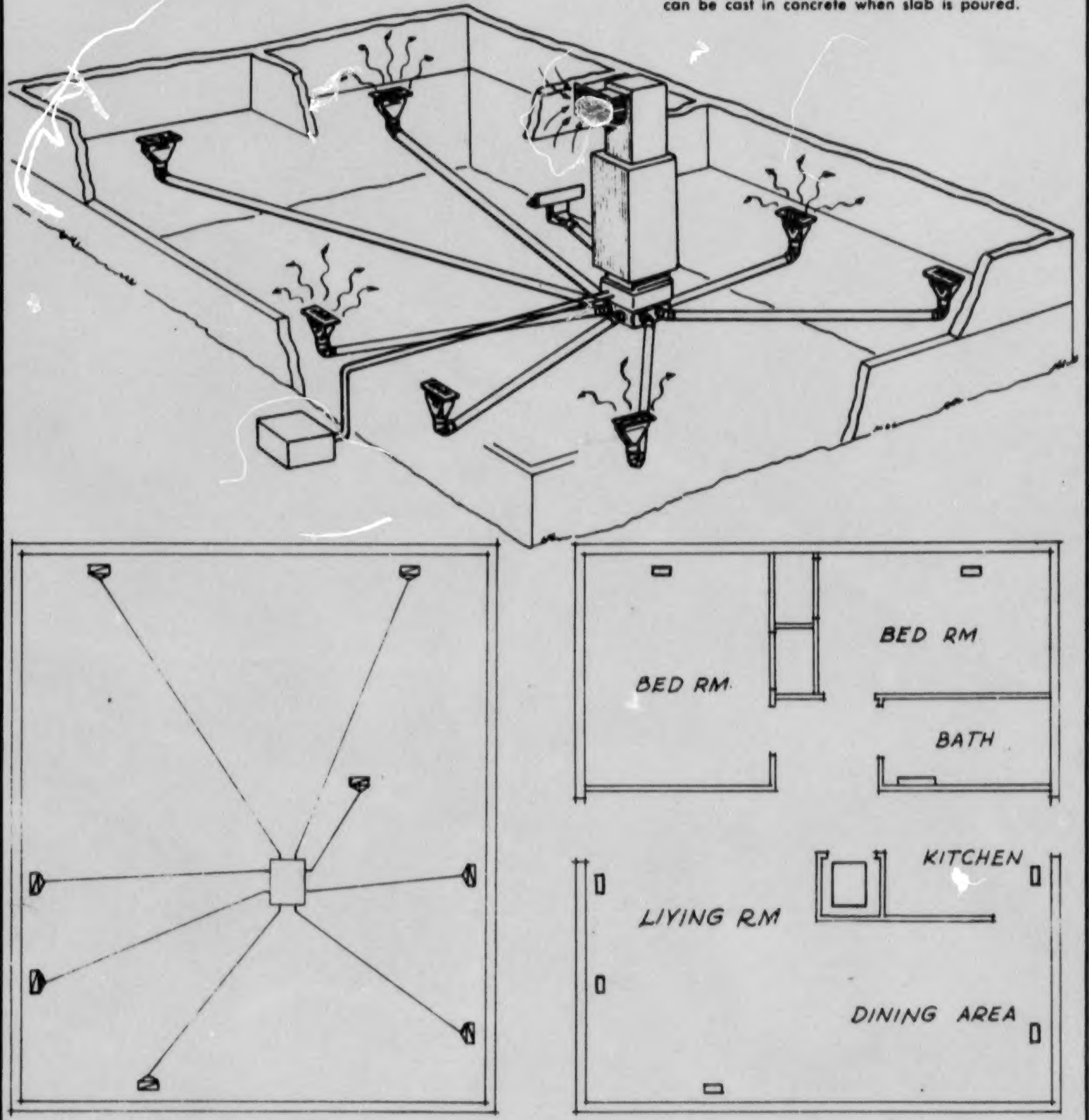


BASEMENT PIPING PLAN FIRST FLOOR PLAN

FIGURE 4.2

RADIAL PIPING SYSTEM, COUNTERFLOW FURNACE

This combination is widely used in compact, one-story houses with crawl space. Warm air plenum under furnace extends into crawl space, where pipes to supply outlets are run beneath joists. Supply pipes and plenum should be insulated. Similar system is used with slab construction where plenum and piping can be cast in concrete when slab is poured.



CRAWL SPACE PIPING PLAN

FIRST FLOOR PLAN

FIGURE 4.3

HORIZONTAL FURNACE SYSTEM

In some cases, where there is sufficient height, a horizontal oil or gas furnace is suspended from joists in crawl space. Extended plenum or radial type supply distribution piping may be used. Plenum, ducts and pipes should be insulated.

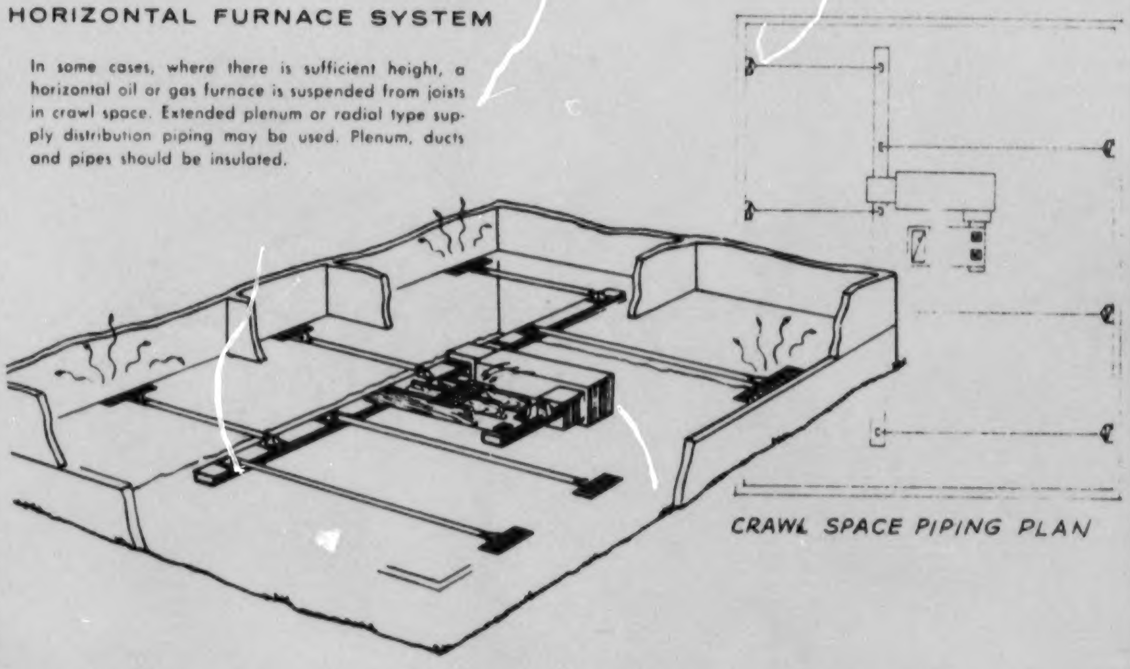


FIGURE 4.4

EXTENDED PLENUM SYSTEM

Large crawl space houses that are rambling or "L" shaped, may require extended plenum ductwork with branch supply pipes to outlets. This especially must be considered where system is to include summer air conditioning.

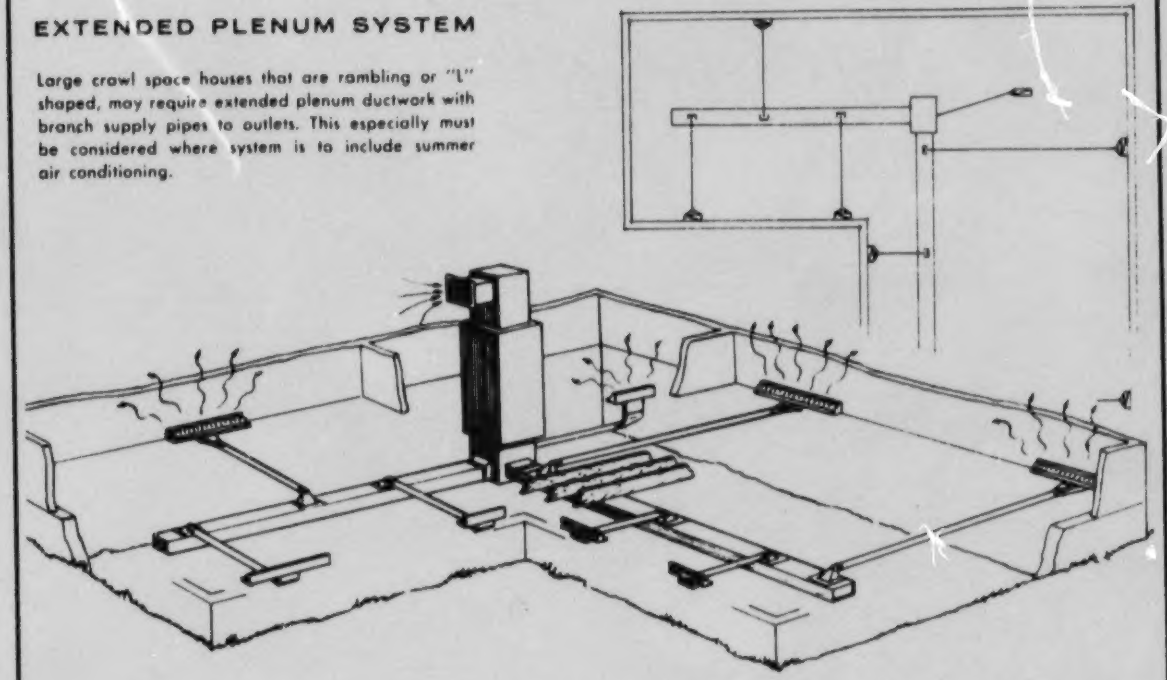
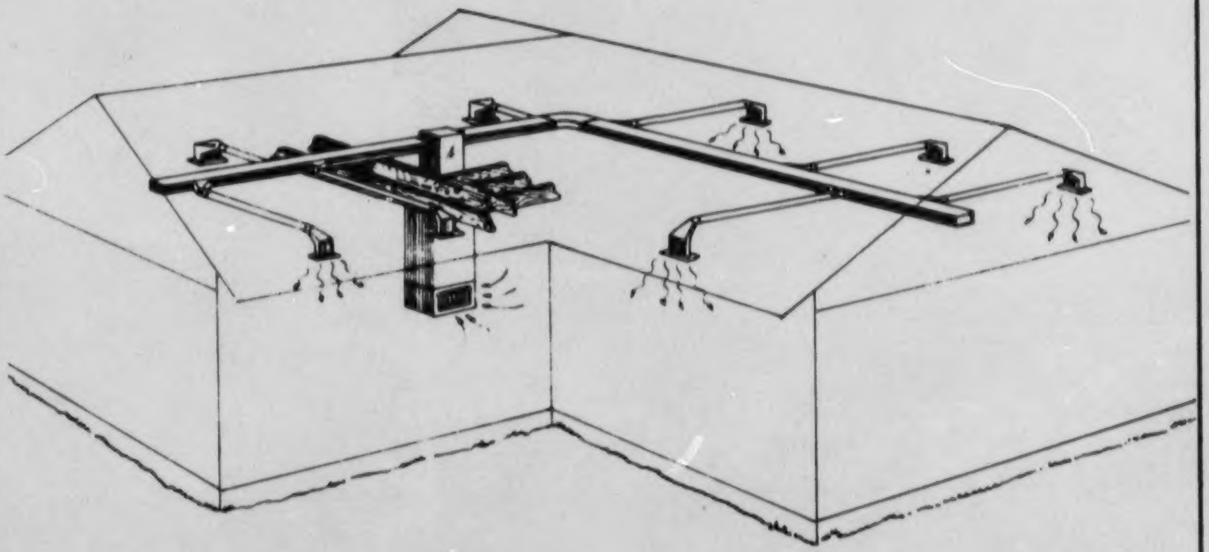
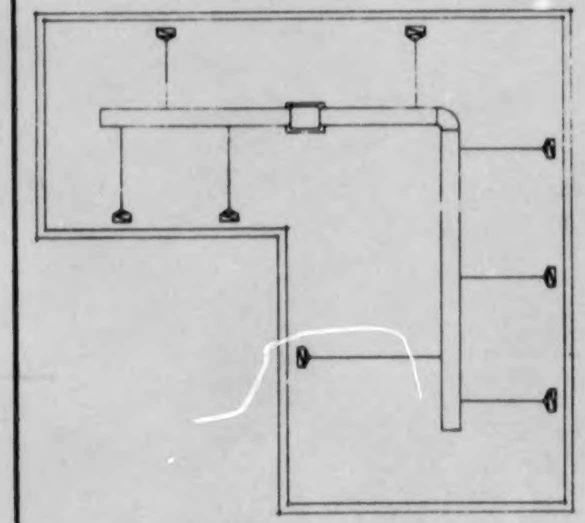


FIGURE 4.5

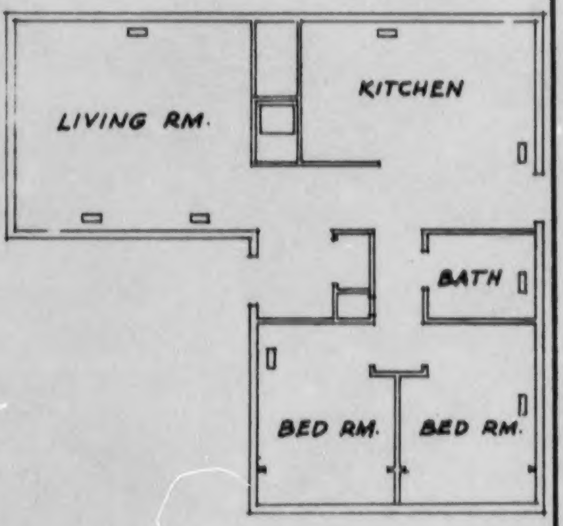
EXTENDED PLENUM IN ATTIC

Unless furnace plenum and supply pipes are cast in the concrete when slab is poured, piping for this type of house must run in the attic. Ducts and piping run across top of joists. Floor diffusers are turned upside down and installed in ceiling near outside walls. Round diffusers centered in room ceilings may be used. Plenum and piping must be insulated.





ATTIC PIPING PLAN

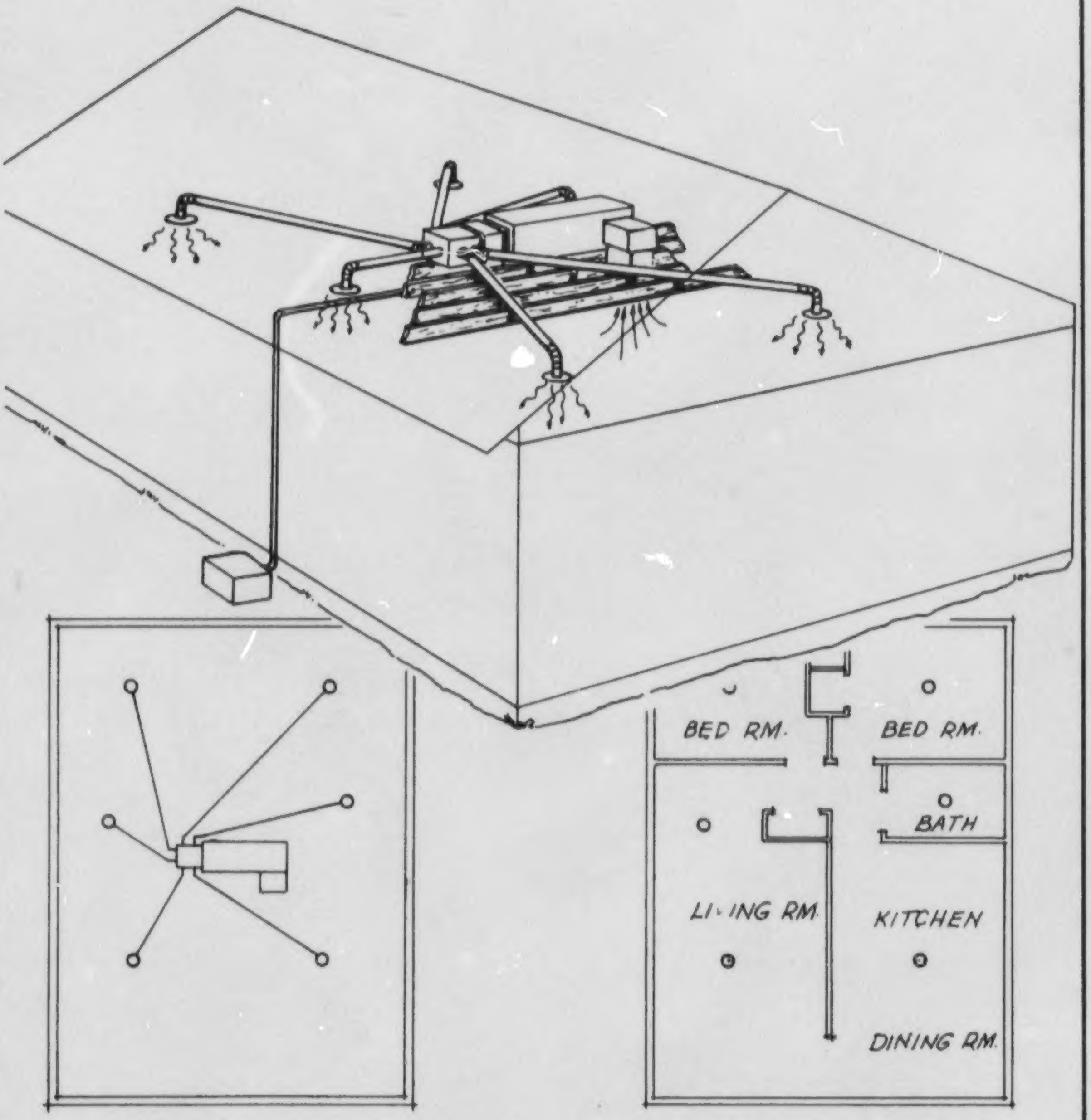


FIRST FLOOR PLAN

FIGURE 4.6

HORIZONTAL FURNACE IN ATTIC

In some installations, a gas horizontal furnace is installed in a properly ventilated attic. Little or no wall cutting is required; diffusers are installed in ceiling; return air grille in ceiling or high wall position. Also an excellent piping system for summer air conditioning. Use extended plenum or radial piping design. Plenums, ducts and pipes must be fully insulated.

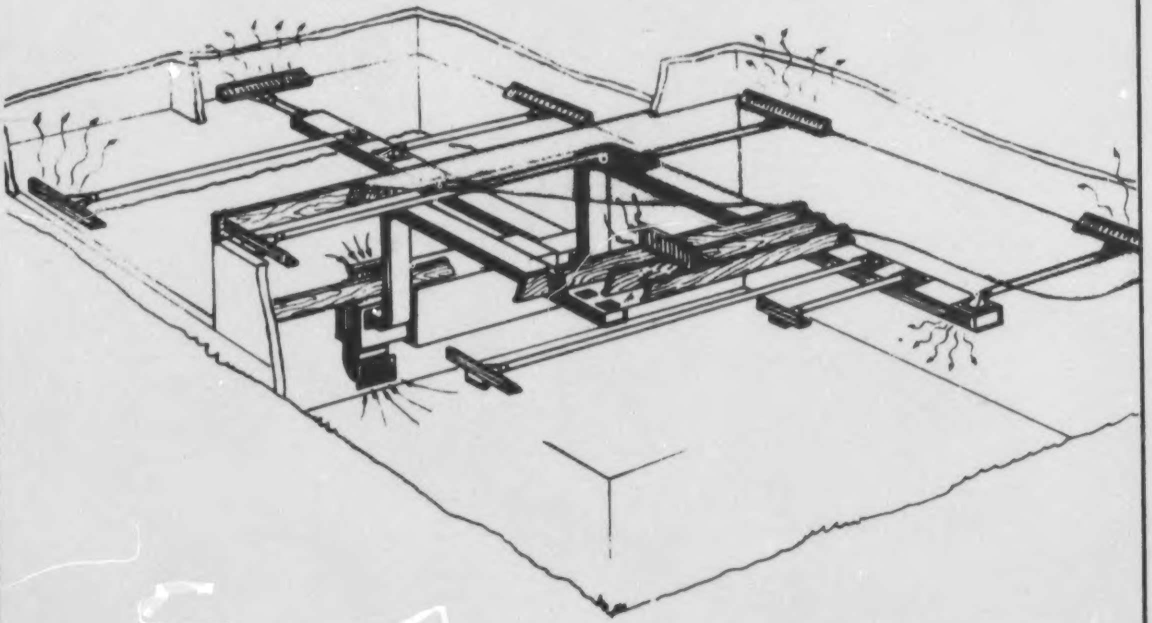


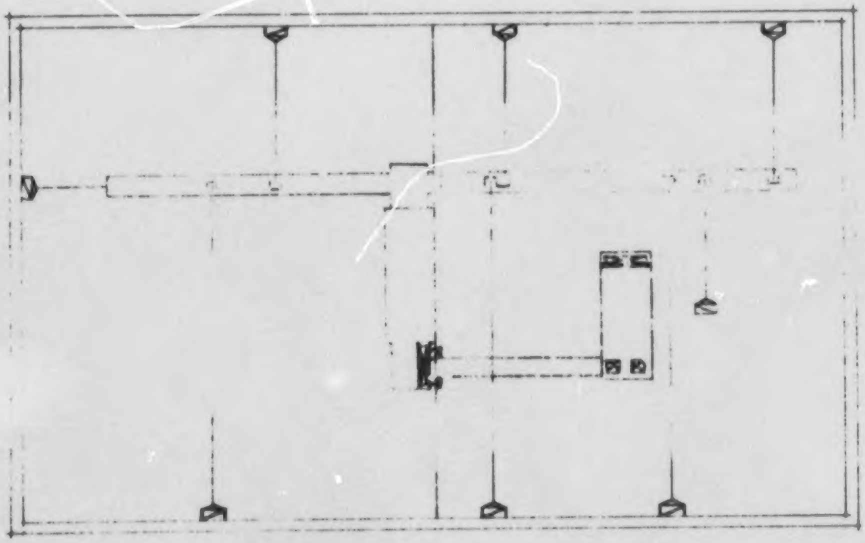
ATTIC PIPING PLAN

FIRST FLOOR PLAN

FIGURE 4.7

In the illustration shown, a horizontal furnace is suspended from joists under second (ground) level. Ducts are run under floor joists of second and third levels. Branch supply pipes take off from top of ducts and run in joist spaces to baseboard diffusers. A register near end of the supply duct furnishes heat to the first level. Return air grilles are used at each level.

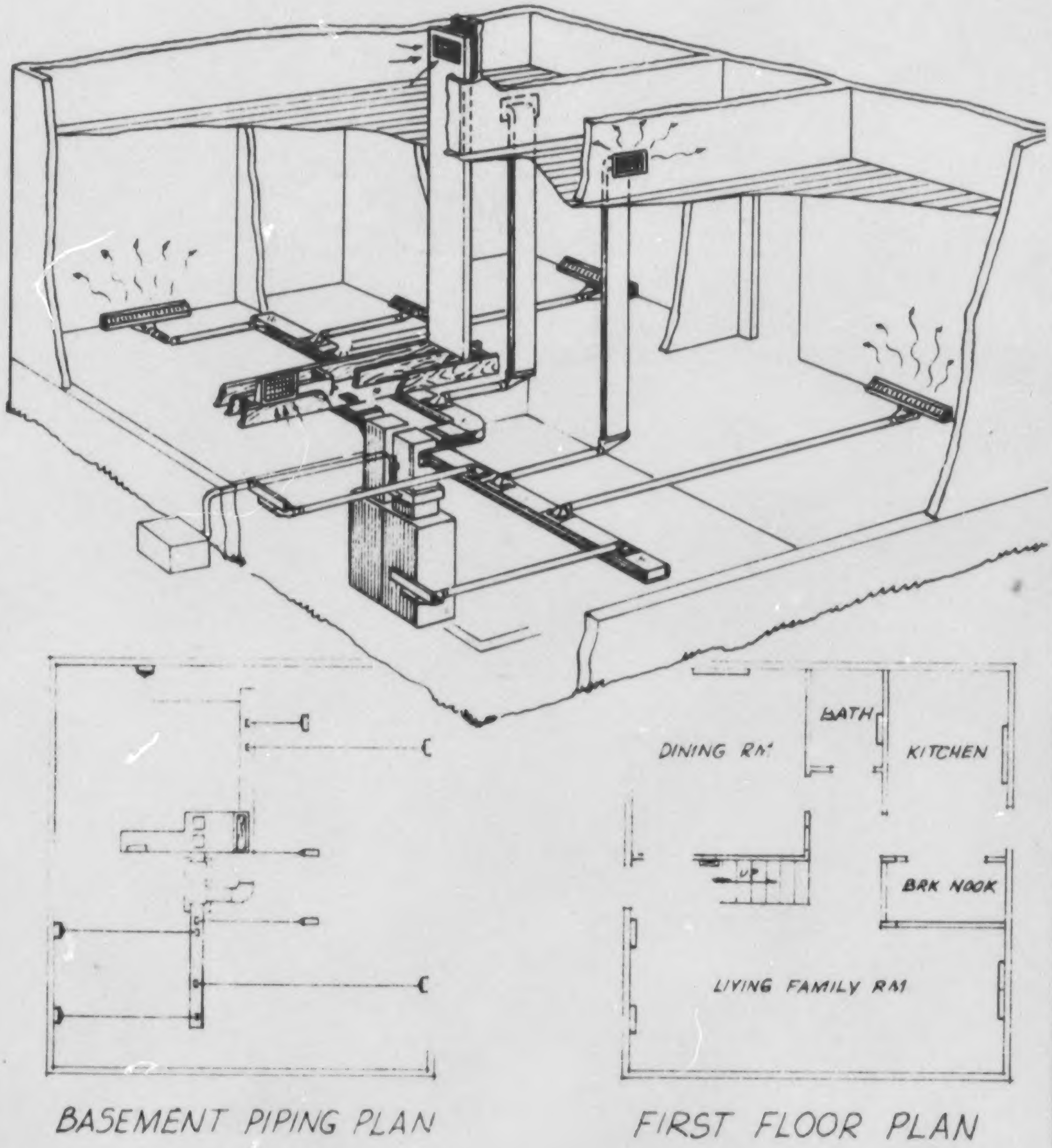




BASEMENT PIPING PLAN

FIGURE 4.8

A basement lowboy furnace with an upflow cooling coil and outside condenser unit provide year around air conditioning for house shown. Conditioned air is distributed to first floor rooms through baseboard diffusers; second floor rooms are supplied by wall stacks extending through interior and connected to registers. A baseboard grille in downstairs hall and a high-wall grille in second floor collect return air, which drops into sheeted joist spaces.



BASEMENT PIPING PLAN

FIRST FLOOR PLAN

FIGURE 4.9

Widely used in far western areas. System illustrated shows horizontal furnace with cooling coil in attic and air conditioning condenser in back yard. Conditioned air is supplied through ceiling diffusers.

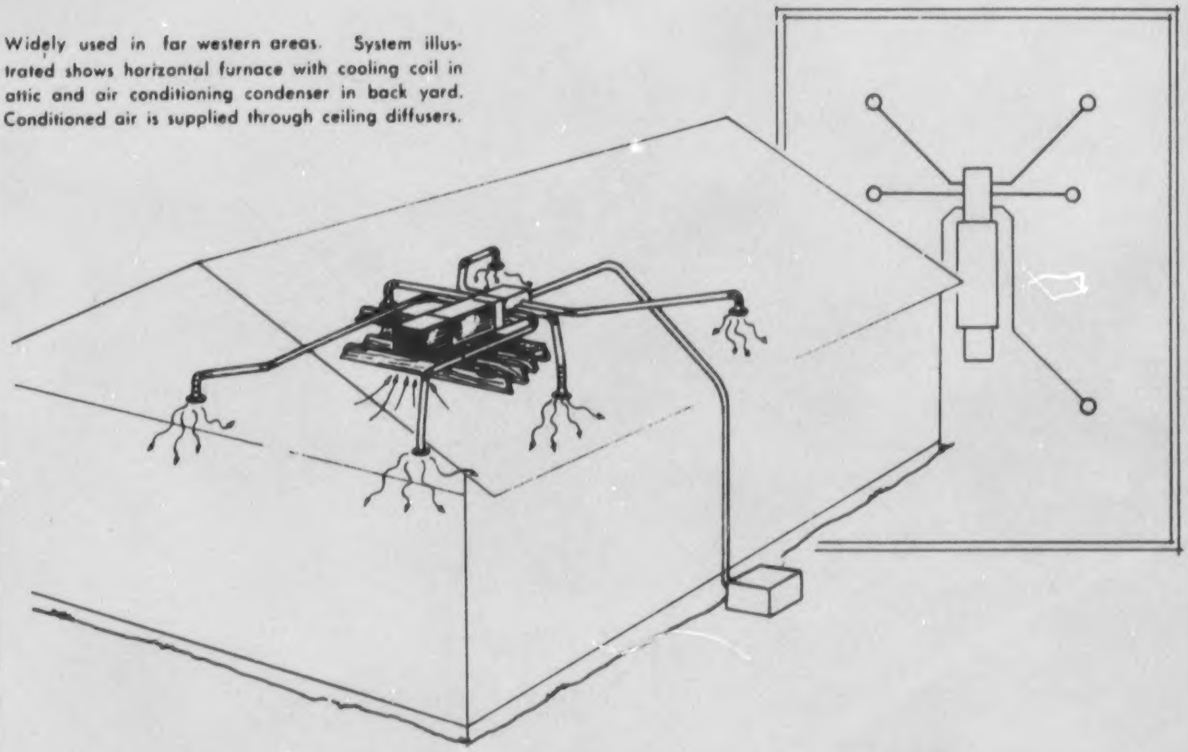


FIGURE 4.10

In the milder climates of the southwest, a dropped ceiling in a central hallway is often used as a main distribution duct. Registers are installed in walls of rooms adjoining the hallway to supply conditioned air. The furnace is installed in a hall utility closet and is mounted on the floor or return air plenum. A grille in baseboard acts as the return air intake.

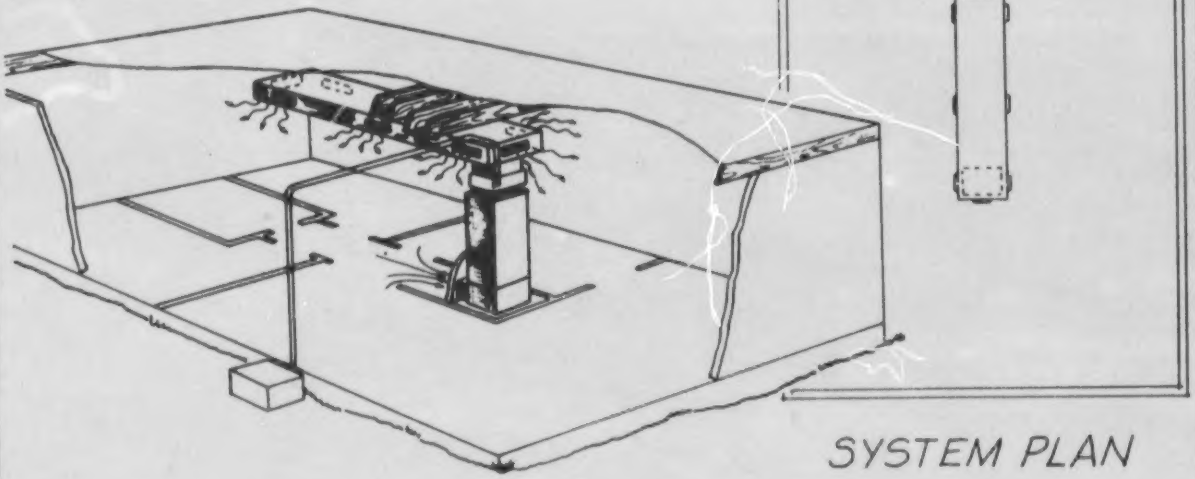


FIGURE 4.11

MODULE XI

ECONOMICS OF ENERGY CONSERVATION

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and post-secondary vocational students. Economics of Energy Conservation may be offered independently or as part of a sequence of three modules in the following order:

Order	Module	Title of Module
1	8	Building Construction Versus Energy Consumption
2	10	Heating, Ventilating, and Air Conditioning Conservation Opportunities
3	11	Economics of Energy Conservation

MODULE XI

ECONOMICS OF ENERGY CONSERVATION

MODULE DESCRIPTION:

This module is designed to be practical in nature by discussing the cost of energy-conservation measures, and the savings and benefits in energy dollars by implementing them. Initial and front-end costs are discussed in terms of payback periods and amortization of investment. The student will learn to develop an overall energy conservation plan by identifying energy-usage savings through operational tradeoffs, cost of implementation, and prioritizing energy conservation measures. Auditing procedures for energy conservation are also discussed.

GOAL STATEMENT:

The objective of this module is to train secondary and postsecondary students in the recognition, implementation, and utilization of energy economics in energy consumption and possible energy conservation.

READING GRADE LEVELS:		SUGGESTED TEACHING TIMES:	
Lecture:	17	Secondary :	3 hours
Lab :	13	Postsecondary:	1-2 hours

MODULE XI

ECONOMICS OF ENERGY CONSERVATION

TERMINOLOGY

Absorption--the process whereby heat extracts one or more substances present in an atmosphere or mixture of gases or liquids, accompanied by physical or chemical change, or both changes of the material.

Absorption chiller--a refrigeration unit based upon absorption refrigeration.

Absorption refrigeration--cooling which is effected by the expansion of liquid ammonia into gas by water. Heat is the primary source of energy.

Active--when applied to building design, refers to the mechanical movement of energy by the use of an external force of energy.

Air change--the movement of a volume of air in a given period; if a house has one air change per hour, all of the air in the house will be replaced in a one-hour period. Air changes are expressed in cubic feet per minute.

Air conditioning--the process of treating air to control temperature, humidity, flow, and odor.

Ambient temperature--temperature of the outside air.

Attic ventilation--in houses, screened openings provided to ventilate an attic space. These are located in the soffit area as inlet ventilators, and in the gable ends or along the ridge as outlet ventilators; can also consist of power-driven fans used as an exhaust system.

Berm--a mound or small hill of earth, man-made.

British thermal unit (Btu)--the amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit; a unit of heat roughly equal to the amount of heat given off by burning a kitchen match.

Building skin--the physical structure which encloses a building.

Bypass loop--a piping arrangement which bypasses or circles the flow of a heat-absorbing medium around, rather than through, a piece of mechanical equipment.

CFM--an abbreviation for cubic feet-per-minute.

Capacity--the usuable output of a system.

Centrified fan--a machine for moving a gas, such as air, by accelerating it rapidly outward in an impeller to a surrounding casing; generally of a scroll shape.

Change of state (phase change)--the change from solid to gas to or gas to solid.

Chimney effect--the tendency of air or gas in a duct or other vertical passage to rise when heated, due to its lower density compared with that of the surrounding air or gas. In buildings, the tendency toward displacement (caused by the difference in temperature) of internal heated air by unheated outside air is due to the difference in density of outside and inside air.

Coil--a cooling or heating element made of pipe or tubing.

Comfort zone--the ranges of indoor temperature, humidity, and air movement under which most persons enjoy mental and physical well-being.

Compression (in a compression refrigeration system)--a process by which the pressure and temperature of the refrigerant is increased to allow for greater heat transfer.

Conduction--a process of heat transfer whereby heat moves through a material.

Convection--transfer of heat by movement of a fluid or gas.

Crack method--a method used in the calculation of air movement from the outside into an enclosed space. The method is based on the rate through one foot of crack between sash and frame, or between door and frame.

DHW tank--abbreviated form for Domestic Hot Water tank.

Damper--a device used to vary the volume of air passing through an air outlet, inlet, or duct.

Dehumidification--the condensation of water vapor from air by cooling below the dew point, or removal of water vapor from air by chemical or physical methods.

Density--the weight per unit volume.

Diurnal cycle--the day-to-night change or cycle of natural phenomenon. An example is the variation of outdoor temperature throughout a 24-hour period.

Dry bulb temperature--a measure of the sensible temperature of air (the one with which most are familiar).

Economizer cycle--a cooling mode which uses cool outdoor air to offset heat gains in buildings rather than using an energy-consuming cooling device.

Electronic air filter--a filter which uses of electricity to set up a static charge which can remove dust and other particulate matter.

Energy--the capacity for doing work, taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical, and chemical; in customary units, measured in kilowatt hours (KWH) or British thermal units (Btu); in SI units, measured in joules (J), with 1 joule equalling 1 watt-second.

Enthalph--a measurement of the total energy content of the air. The total energy content is composed of both sensible and latent heat as measured by the dry-bulb and wet-bulb temperatures.

Evaporative cooling--lowering the temperature of a large mass of liquid by utilizing the latent heat of vaporization of a portion of the liquid; cooling air by evaporating water into it.

Flow rate--velocity at which a fluid travels, usually through an opening or duct.

Frequency of occurrence--the number of times a given event will occur during a given period of time.

GPM--an abbreviation for gallons-per-minute.

Greenhouse effect--the condition of the earth's atmosphere in trapping heat from the sun. The atmosphere acts like a greenhouse by admitting the sun's shortwave radiation but by blocking the exit of long wavelength radiation re-emitted by the earth or other warmed objects.

Heat capacity (sometimes called thermal capacity)--a measure of the heat required to raise the temperature of a specific quantity of material by a given amount.

Heat dissipator--the method of transmitting energy or power out of a system in the form of heat.

Heat exchanger--a device used to transfer heat from one medium to the other.

Heat gain--an increase in the amount of heat contained in a space, resulting from direct solar radiation and the heat given off by people, lights, equipment, machinery, and other sources.

Heat loss--a decrease in the amount of heat contained in a space, resulting from heat flow through walls, windows, roof, and other building envelope components.

Heat pump--a reversible refrigeration system that delivers more heat energy to the end use than is put into the compressor. The additional energy input results from the absorption of heat from a low temperature source--the combination heating and cooling unit. It operates like a normal cooler in summer, and in winter operates in reverse, ejecting warm air indoors and cool air (or water) outdoors.

Heat wheel--a device used in ventilating systems which tends to bring incoming air into thermal equilibrium with existing air. As a result, hot summer air is cooled and cold winter air is warmed.

Humidifier--a device which adds moisture to air.

In-line pump--a pump which is supported by the piping system.

Incident--usually used in the term "incident radiation", which is the amount of energy striking a collector surface before entering the collector.

Infiltration--the uncontrolled flow of air into and out of a building through cracks, openings, doors, or other areas which allow air to penetrate.

Initial cost--the original price of an item or system.

Insulation, thermal--any material high in resistance to heat transmission that, when placed in the walls, ceilings, or floors of a structure, reduces the rate of heat flow.

Kilowatt Hour (KWH)--unit of electrical energy consumption which equals about 3,400 Btu.

Latent heat--a change in heat content that occurs without a corresponding change in temperaure, usually accompanied by a change of state.

Peak load--maximum predicted energy demand of a system.

Permeance perms--the ratio of water vapor flow to the vapor pressure difference of the surfaces; permeance is expressed in perms or (grains)/(Sq.Ft.)/(Hr.), and of mercury vapor pressure difference.

Psychrometric--pertaining to the device (psychrometer) comprising two thermometers, one a dry bulb, the other a wet or wick-covered bulb, used in determining the moisture content or relative humidity of air or other gases.

R-value resistance--the resistance of a material to the flow of heat or energy.

Reflectance--a property of a material indicating the percentage of light that is reflected when a certain amount of light strikes the surface of the material or is transmitted through it.

Relative humidity--the ratio of the amount of water vapor at a given temperature to the maximum amount of water vapor that could be held as vapor.

Sensible heat--heat that results in a temperature change.

Set-back--the lowering of the thermostat setting. The technique is used to reduce the amount of heat required to heat a space.

Set-up--the raising of the thermostat setting. The technique is used to reduce the amount of cooling required to cool a space.

Shortwave radiation--a term used loosely to distinguish radiation in the visible and near-visible portions of the electromagnetic spectrum (roughly 0.4 to 1.0 micrometers in wavelength) from longwave radiation (infra-red radiation).

Sling psychrometer--a psychrometer in which the wet and dry bulb thermometers are mounted upon a frame and connected to a handle at one end by means of a bearing or a length of chain. It may be whirled in the air for the simultaneous measurement of wet and dry bulb temperatures.

Solar intensity--the amount of solar radiation.

Solenoid valve--a value actuated by a an electronic impulse for controlling the flow of gases or liquids in pipes.

Space heating--interior heating of a building or room.

Stagnation--the condition of a fluid or gas unstirred by a current or flow.

Thermal comfort--the zone in which a majority of the human population would feel comfortable (not too hot or too cold).

Thermal lag--the ability of materials to delay the transmission of heat; can be used interchangeably with time lag.

Thermal sensation--the ability of the body to sense the temperature as being too hot or too cold.

Time lag--the time between a cause and a resultant effect, as between occurrence of heat input on an exterior surface of a wall and the time until the heat is transmitted to the interior wall surface.

Ton (of air conditioning)--the thermal refrigeration energy required to melt one ton of ice (2,000 pounds); equals 12,000 Btu.

"U" value--a coefficient which indicates the energy (Btu) which passes through a component for every degree (Fahrenheit) of temperature difference from one side to the other under steady state conditions.

Vapor barrier--a component of construction which is impervious to the flow of moisture or air.

Vapor pressure--the force exerted when moist air attempts to seek equilibrium by migrating to areas with less water vapor.

Ventilation air--outside air that is intentionally allowed to enter an interior space.

Weatherstripping--material such as foam, metal, or rubber strips used to form a seal around windows, doors, or openings to reduce infiltration.

Wet bath temperature--the lowest temperature attainable by evaporating water into the air without altering the energy content.

MODULE XI

ECONOMICS OF ENERGY CONSERVATION

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MODULE XI

ECONOMICS OF ENERGY CONSERVATION

PRETEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. It is not usually possible for most individuals to cut their energy use by a significant factor without lowering their standard of living.

   a. true b. false

2. Discretionary income in the family budget lies principally in two areas:

   a. housing and clothing
   b. education and recreation
   c. food and energy

3. A car that is driven primarily in the city will require a change of oil more often than an automobile driven on the highway .

   a. true b. false

4. Human comfort in any particular area is a result of the loss of heat from the skin compared to the amount of heat internally generated by the body.

   a. true b. false

5. Direct gain is an _______ in the winter:

   a. advantage b. disadvantage

6. Overall infiltration surges and pulses can be controlled by air locks.

   a. true b. false

7. Energy used in cooking meals can be reduced by using:

   a. the stove oven
   b. top burners
   c. microwave oven

8. Can we conserve energy by using cloth dishtowels rather than paper towels?

   a. yes b. no

9. Plants, growing high on a north wall, can help reduce indoor heating costs.

   a. true b. false

10. When beginning a program of energy conservation in your home, it is important that you consider the kind of lifestyle you desire.

    a. true   b. false

11. The minimum constant demand on a utility-generating facility is termed the "baseline load."

    a. true   b. false

12. The maximum value of the instantaneous load is called the:

    a. baseline load
    b. demand peak

13. There are actually two major components in the time profile of the power demand.

    a. true   b. false

14. All power companies have the same load-following curve or load profile.

    a. true   b. false

15. Power systems, such as hydroelectric generators, are not capable of being ON and OFF with short-duty times.

    a. true   b. false

16. In some parts of the nation there are different power rates for the summer and winter. The rates vary because of demand and the availability of fuel.

    a. true   b. false

17. The conservation of electricity will not only reduce your bill, but it will also ensure reduced growth rates and thus a reduction in future bills.

    a. true   b. false

18. The energy in coal, oil, and natural gas came partially from the sun.

    a. true   b. false

19. The photosynthetic process has an efficiency of about _______ percent:

    a. 1   b. 5   c. 10   d. 20

20. In the production of electricity from fossil fuels, the maximum efficiency is approximately:

    a. 1/2   b. 1/3   c. 3/4   d. 2/3

MODULE XI

ECONOMICS OF ENERGY CONSERVATION

ANSWERS TO PRETEST

1. b. false
2. c. food and energy
3. a. true
4. a. true
5. a. advantage
6. a. true
7. c. microwave oven
8. a. yes
9. a. true
10. a. true
11. a. true
12. b. demand peak
13. a. true
14. b. false
15. b. false
16. a. true
17. a. true
18. b. false
19. a. 1
20. b. 1/3

MODULE XI

ECONOMICS OF ENERGY CONSERVATION

UNIT I

ENERGY USE AND DEMAND PROFILES

UNIT OBJECTIVES

1. Discuss the prevailing American philosophy toward energy.
2. Explain the analysis of cash flow from income.
3. Discuss the difference between baseline load for utilities versus the instantaneous load demand.
4. Recognize the baseline load and peak demand periods during the year for natural gas and electricity.
5. Discuss the various forms of generating electricity for domestic use.

MODULE XI

ECONOMICS OF ENERGY CONSERVATION

UNIT I

ENERGY USE AND DEMAND

LECTURE	ACTIVITIES

INTRODUCTION

Our modern technical society runs on energy and the byproducts of energy production. Life as we know it is impossible without the expenditure of both energy and resources. Each individual requires a certain amount of energy consumption or expenditure every day of life, depending on interests, needs, and conservation practices, to support personal lifestyle. This use of energy is either direct, in the form of light, heat, and transportation, or indirect, in the form of materials, food, products, and clothing utilized or consumed. There is no lifestyle or philosophy, including those alternative lifestyles and simpler technologies, which do not include some expenditure or use of energy. The purpose of this module is to develop background knowledge and information that will be useful to individuals who are interested in determining, limiting, and/or controlling their energy use. It will also help individuals learn how they can minimize their energy impact on society; how they can make energy policy decisions; and use a planned approach to the consumption and conservation of energy. It is possible for most individuals to cut their energy use by a significant factor without having to lower their standard of living. In fact, in many cases energy conservation can raise one's lifestyle. Using the contents of this module each can make energy policy decisions with respect to personal life. Thus, each of us can determine the use we will make of our energy dollars.

When one does an analysis of cash flow from income, very few items in one's budget will be found to be discretionary. The cost of paying for housing, baseline utility charges, and the expenses of employment are usually fixed. Discretionary income in the family budget lies principally in two areas: food and energy. Unhappily in the past, many Americans, when caught in a declining cash-flow situation with increasing food and energy prices, have chosen to cut into that part of discretionary funds which are used for food. This leads to dietary problems, lowered quality of life, cutbacks in activities, etc. The purpose of this module is to offer a second alternative for the reduction of discretionary expenses: namely, the conservation of energy use to reduce the size of utility bills and thus reduce the fraction of the total budget spend on energy, and to reduce the dollards spent on energy. This reduction in dollars spent can easily be an absolute reduction even in this time of repidly rising utility rates. It should be noted that money spent by an individual for food is money spent on self, while money needlessly spent of utility bills is money wasted. However, the basic philosophy of the person considering this module should be that unnecessary funds given to the utility company for excessive energy purchases (which are not really needed and which should be saved by conservation) are monies that have been thrown away or which might just as well have been scattered to the wind.

Utility companies--confronted with rising power demands, increased pollution requirements, increased fuel costs, and greater potential for degradation of the environment--are caught in a bind between the required mandate as a power monopoly to provide power on demand and the fact that additional power is becoming progressively more expensive to produce. The utility company, because of the way equipment is financed, must not only pay for existing equipment, but must charge existing customers at rates which will make it possible to finance bonds, etc., sold to cover the costs of developing and bringing on new power plants. Thus, an individual's utility rates go up not only because of expansion required by anticipated demand. In this module, we will look at a number of different aspects on energy conservation. These will include:

1. Energy use and demand profiles,
2. Energy conservation methods and trade-offs,
3. Energy costing and accounting,
4. Developing one's own energy-conservation priorities.

ENERGY USE AND DEMAND PROFILES

The person who turns on an electric or gas appliance is the final user of an energy production process which begins where the raw resources are extracted from the earth, or when a natural energy source (such as falling water) is harnessed. These resources are then processed for upgrading and standardization, as in the case of natural gas, or they produce a final product such as electricity. The

For the first activity, the students should get hold of a standard mineral reference such as the statistical abstracts of U.S. or material handed out by the teacher. The students should plot the demand for oil, natural gas, and coal, and for electricity as a function of year on graph paper or using a bar graph. A smooth curve should be fit through the demand value and the consequences of different growth patterns for the future should be discussed.

utility company has to provide, because of monopoly privileges, power on the demand of their customers. This means that as each individual turns ON and OFF the discretionary appliances in the house, and as the automatically controlled appliances, such as furnaces, refrigerators, etc., cycle the demand for power production by the utility changes. This individual demand, summed up for each customer, is the power requirements of a complete community, and produces what is known as a load profile, or most commonly, the instantaneous power load. The actual time profile of the power demand consists of two major components. The first component, as shown in Figure 1.1 is the baseline load. This is the minimum constant demand on the utility during any particular pre-defined period. The baseline load can be adjusted for daily, monthly, or seasonal demand anticipations. The baseline load is produced by utility-generating facilities which run continuously. These include coal-fired boilers producing steam for the generation of electricity, and in some parts of the country, nuclear systems. The other part of the demand is called the instantaneous load demand produced by the load following, or instantaneous capacity of the utility system. The maximum value of the instantaneous load is called the demand peak. The instantaenous load is the part of the demand which changes by hour and by day, but in general, demand peaks appear in the morning and in the evening. The actual size and shape of the demand peaks are a function of season, weather, a particular location, and the characteristics of the clientele being served. A power company As a second part of this activity, students should calculate the average power consumption for each individual in the United States. This should then be compared with the world's population to see what the power consumptions would be for the world if everyone used poewr the same level that the U.S. does. The average power consumption for different countries of the world will be attached to the activity for additional analysis.

Students, using their energy and mineral references, should also look at the projected reserves of the various fossil fuels and natural resources. Using these projections, they should determine the amount of time left for the use of each of the resources assuming they are equally available down to the last percentage. This activity should be done for the following cases:

1. Steady demand at a current level.
2. An increasing demand of 5% per year.
3. An increasing demand of 10% per year.
4. An increasing demand of 15% per year.
5. A decreasing demand of 5% per year.
6. A decreasing demand of 10% per year.
7. A decreasing demand of 15% per year.

The upper exercises are to allow the student to see the consequences of different growth rates, and the consequences of reducing by conserving the demand for power. It should be noted that as the fuels disappear, other consequencs that are not foreseen will be shown in these simple exercises, namely--that it takes energy to convert

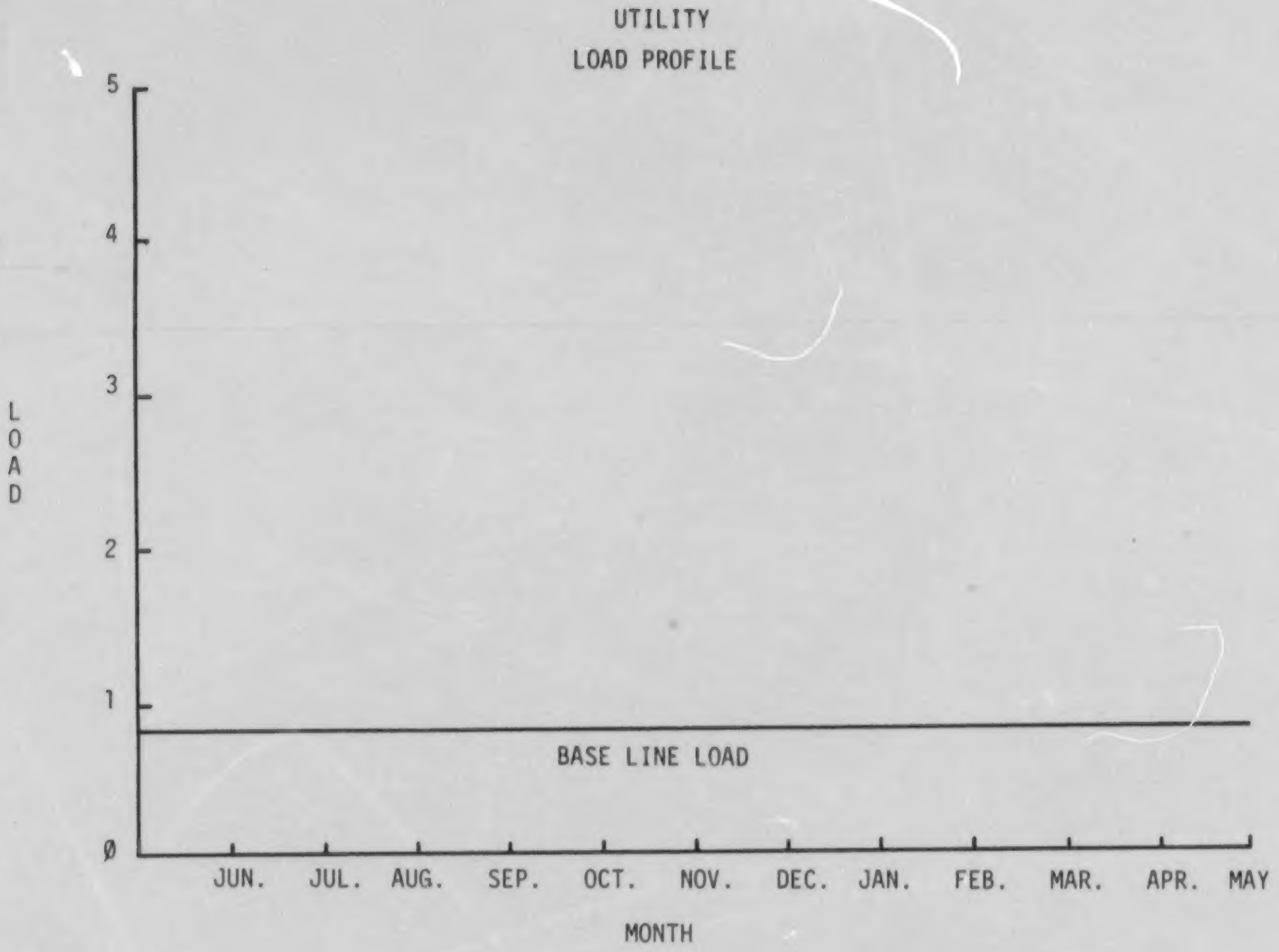
UTILITY
LOAD PROFILE
LOAD
5
4
3
2
1
0
BASE LINE LOAD
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
MONTH

FIGURE 1.1

which has a large number of industrial and commercial clients will have a different load-following curve or load profile. This peak load or peak demand must be produced by power systems which can be turned ON and OFF, or brought on and taken off the power net over relatively short time intervals. Power systems, which are capable of being ON and OFF with short duty times, are those such as hydroelectric generators, gas turbines, oil-driven turbines, and in some parts of the country, nuclear power plants which have been used to produce the load-following power and to meet the peak demand. Because these other power plants are not used all of the time, they cost more per kilowatt hour of capacity to operate and maintain, and are less efficient to operate in most cases since they are used only for peak power production and high load demand periods. Because they must be turned on and off in short cycles or fairly rapidly, peak power production is much more expensive than baseline load power production per kilowatt hour. Nuclear power plants are used in some parts of the country for peak production because control rods can be inserted to reduce the rate of heat production fairly rapidly. However, the control rods do not completely stop the disintegration of the radioactive fuel in the core of the reactor. The chain reaction is only slowed, and the enhanced decays of individual radioactive nuclei continue--the decay rate being a function of the mean available neutron flux in the core with the control rods in place for standby operation of the facility. Therefore, a nuclear power plant, if it is loaded and has the control rods coal to a liquid fuel, and energy to convert coal to natural gas or other portable materials. Also, as one digs deeper into the earth for minerals or pumps on deeper weels or smaller reservoirs the amount of energy required per unit of energy extracted from the earth becomes greater. With respect to minerals, as the lower grade deposits are mined and worked and subsequently smelted, the energy required per unit production of metal or mineral increases. Increased energy costs per unit of energy, coupled with growth in energy demand and cost, means that you are multiplying increases in energy cost times inreases in energy demand to give the non-linear energy and materials cost increases with time.

Students should proceed before a specifically assigned class to gather copies of at least one and preferably two years of utility bills used by their family. The actual dollar amounts are of no interest in this exercise. Using these receipts, the student should note the kilowatt-hours of electricity and the thousand cubic feet of natural gas that were billed for each month. It would also be helpful to tally the water consumption bills for these same periods with respect to the number of gallons or number of cubic feet of water used.

In this activity, the students are to use graph paper to plot the monthly power requirements: namely, the electricity and gas used, as a function of months of the year. They should put, per the example in Figure 1.2, the months along the ordinate and the gas use up the right abscissa and the electric up the left abscissa. If they also have water-use information, that should be tabularly formed

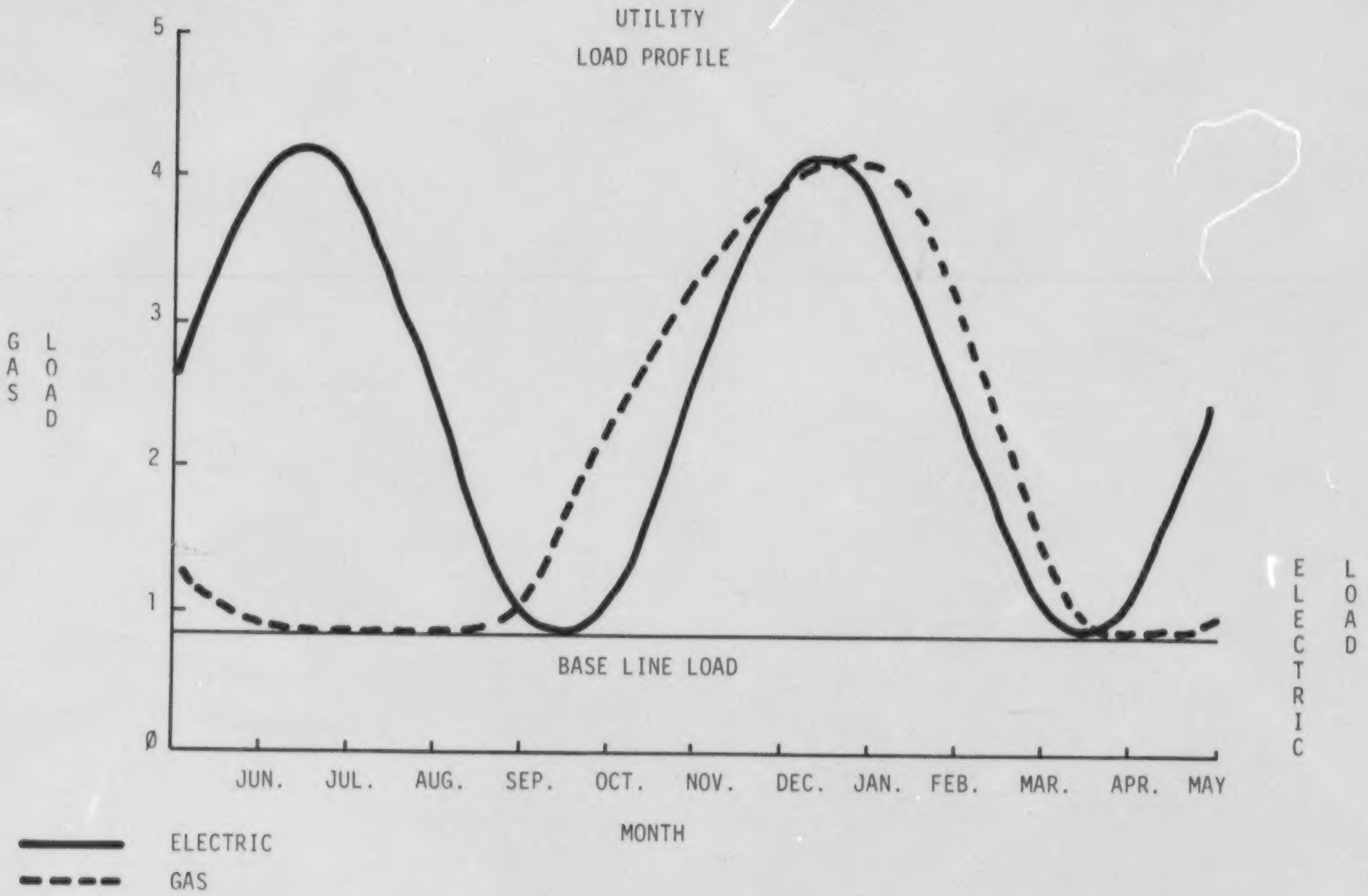
UTILITY
LOAD PROFILE
5
4
3
2
1
0
GAS LOAD
ELECTRIC LOAD
BASE LINE LOAD
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
MONTH
ELECTRIC
GAS

FIGURE 1.2

kept in, will itself still require a replacement fuel in the core at a predetermined time interval even if no power is ever produced. . In general, peak power production for peak demand can cost 10 to 60 times what baseline costs when one compares the cheapest baseline plant to the most expensive turbine peak power-following systems.

Because of changes in demand with season, many parts of the U.S. have different power rates for summer and winter electricity. These rates vary not only because of demand, but because of the availability of fuel. An example of this in recent years was that in many parts of the midwestern northern United States, the natural gas used in winter for heating buildings was used in the summer to produce electricity. Government changes in policy and availability of fuels have required many utility companies to switch to coal-fired electric generators. These will cost additional funds to build and will require that the utility companies sell more bonds than normal demand-increase requires. The consequences of this will be increased power plant construction, fuel demands, increased electric rates, etc. Thus, an individual should conserve for a number of reasons which have nothing to do with philosophy or alternative technology beliefs, namely:

1. Conserving electricity will reduce the size of your immediate utility bill.
2. Conserving electricity will ensure reduced growth rates and thus a reduction in the cost-per-unit electricity on future bills.
3. Conserving electricity saves scare, non-renewable natural resources.

and analyzed to decide whether it also should be included on the graph. If it is included on the graph, a second set of axes should be included up the right side along with the gas use. This would be especially true for those who have all-electric homes. Once this has been plotted, the students should determine what the baseline loads are as a function of season and the overall yearly baseline load. This is the power demand at the minimum period during the whole year, or the minimum power required for the period of either the winter heating or the summer cooling season. Students should also determine the peak profile structure and the peak demands for power.

This information will give them an idea of power use demands in their own homes.

The coal, oil, and natural gas used to produce energy are characterized by two major facts: (1) They are highly concentrated forms of energy which are easily transportable and readily adapted to a large number of small power system usages, and (2) the fuels which are called fossil fuels are in fact fossilized solar energy. These fuels are the result of pre-historic biomass produced by photosynthesis which captured the current available enrgy initially from the sun. The photosynthesis process has an efficiency of about 1 percent maximum. Obviously, the biomass that survives partial decay and compression into coal and oil, assuming both are produced from plant material, would have a slightly less percentage of conversion efficiency. This coal and oil is then burned. In the case of the production of electricity, the maximum efficiency is approximately one-third. This means that you are, when burning fossil fuel, getting one-third of 1 percent of the incidence solar energy available converted into heat. Figure 1.3 shows that it takes 15 pounds of coal, 1 gallon of oil, and 120 cubic feet of natural gas to produce 100,000 Btu of heat. If this represents less than one-third of one percent of the useful conversion of each of these fuels into heat, it is clear how important it is to use it the most efficiently. Obviously, additional losses will reduce this figure by the time the electricity reaches your lamp or other appliance. If one takes natural gas and burns it directly in a boiler such as a hot water heater, one gets approximately 68 percent energy conversion efficiency to heat. This means that in the case of gas, one gets 2/3 of 1 percent efficiency, minus plumbing and heat-

Over a period of a couple of days, each student should, after having learned in Module III to read an electric or gas meter, read the electric power and gas consumption on the smaller dials at hourly intervals for at least two days and plot this information. In periods of high-demand use, the student should read at fairly short intervals. This can be done for more than one season or for different types of weather days. Students can determine which appliances use large amounts of power by working as teams and either opening refrigerator doors, starting up the furnace or air conditioner by adjusting the thermostat, or wating until these turn on to see how fast the meter moves and how much power is used per minute for the different types of appliances. The student can also leave a door or window open to see how infiltration rates increase the amount of time that a furnace runs.

Using the data included in the laboratory module and class modules, the students should determine what their expected power use is as a function of the appliances used in their homes. To do this, they should look at the hourly expected distributions and couple this with the watt and currents that they have found on the electrical power consumption tags and stickers on the appliances used. This will be done using information covered in Module IV and class presentation. After having plotted their actual energy use, they should plot a scenario of what they believe a maximum energy use couild be for their home. They should also plot an energy-use reduction which follows the recommendations they ing cycle losses. The water heater or a water-heating boiler which is used to produce domestic hot water will cycle when cooled whether or not water is extracted and used. These finite inefficiently produced nonreproducible energy products, when compared to possible overall efficiencies from renewable resources, are too valuable to be burned to produce heat, etc. Therefore, as a scenario in the transition from present power systems and power usage to the alternative systems which must be used as the resources of the world deplete, energy conservation is a necessary step to ensure that these irreplaceable resources survive long enough so that alternatives can be developed and put into use. One might note that oil products are used in the production of clothing, plastics, and penicillin. These are much more valuable uses for oil than burning it at approximately 1,700°F to keep a house at 68-70°F.

have learned in this and previous modules. Students should then compare all three curves to find whether they are medium, high, or lower power users compared with what they consider a maximum potential use and the minimum optimum use they have previously plotted.

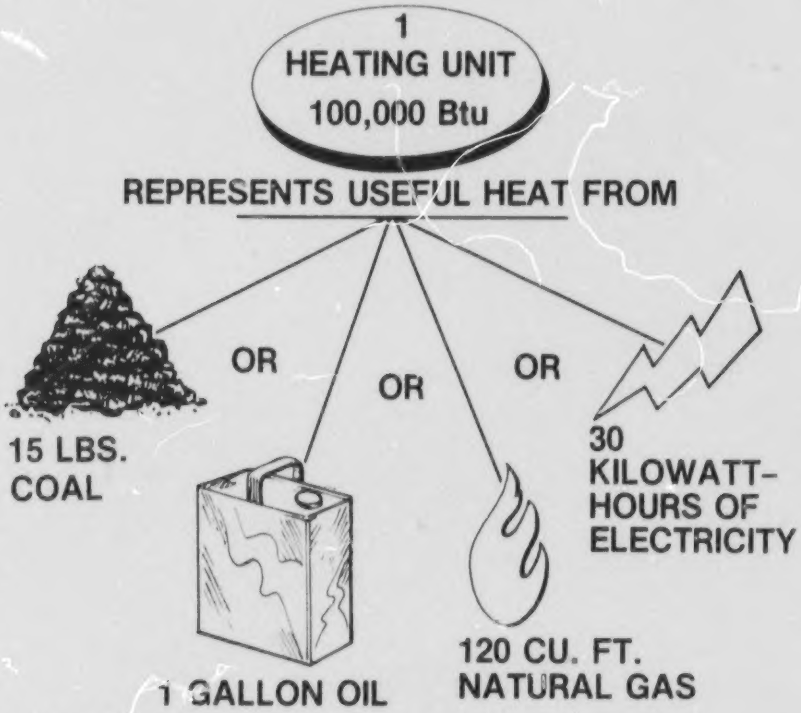
1
HEATING UNIT
100,000 Btu
REPRESENTS USEFUL HEAT FROM
OR
OR
OR
15 LBS. COAL
1 GALLON OIL
120 CU. FT. NATURAL GAS
30 KILOWATT-HOURS OF ELECTRICITY

FIGURE 1.3

MODULE XI

ECONOMICS OF ENERGY CONSERVATION

UNIT II

ENERGY USE AND DEMAND PROFILES IN THE HOME

UNIT OBJECTIVES

1. Identify different appliances in the home and determine the cost of operation for each.
2. Determine the efficiency and cost of operation for various types of lighting.
3. Identify and discuss efficiency of an automobile.
4. Discuss energy conservation measures in handling, driving, and repairing an automobile.

MODULE XI

ECONOMICS FOR ENERGY CONSERVATION

UNIT II

ENERGY USE AND DEMAND PROFILES IN THE HOME

LECTURE

A. APPLIANCES

Energy use in the home comes from many appliances and power devices. The devices listed in Figures 2.1 and 2.2 should cover most of the different appliances, including rated and expected power use and the average mean time of use that can be found in the average home, assuming normal demand and use of the particular appliance. To determine the daily kilowatt or watt-hours or watt-seconds, multiply the wattage of each appliance used by the time of use.

B. LIGHTING

Using the lumens information in previous modules, one should look at lighting requirements in the residence as a function of the ideal intensity levels of different activities. Consider the efficiency of illumination from incandescent and fluorescent bulbs, and evaluate the power consumption needs of different types of lighting and lighting fixtures to illustrate the consequences of over-illumination. The consequences of using natural back lighting coupled with natural illumination for general low-level minimal lighting or reading should be discussed as a consequence of the illumination levels. Because of the greater efficiency of fluorescent lighting, it is obvious that the use of such lighting in the ceiling and the use of lighting directly under

ACTIVITIES

An activity which can be used as a laboratory and demonstration exercise in the classroom consists of the following. One should take expected times for particular cooking processes or preparation processes and compare the time required for doing this in an oven, microwave oven, slow cooker, and counter top oven toaster using the information given in Figures 2.1 and 2.2.

Students should gather temperature data from newspapers for hourly rates, and for mean daily highs and lows over a period of days. Using this data, they should calculate the daily value of the temperature in terms of its heating or cooling degree days. They should also determine what the degree day values for particular temperatures and temperature changes are. This analysis can be done on a daily, hourly, or minutely basis depending upon the complexity of the data desired.

ELECTRIC APPLIANCES

Electric Product	Typical Wattage	Cost	
Air Conditioner			
Room			
Bedroom	900	$ .028*	--hour
Family or Living Area	1500	.046*	--hour
Multiple Rooms	3000	.093*	--hour
Central (EER 8)**			
3 ton	4500	.112*	--hour
5 ton	7500	.187*	--hour
Baby Food Warmer	165	.0012	--10 minutes
Blanket	175	.03*	--night
Blender	385	.0003	--minute
Broiler (Portable)	1500	.031	--30 minutes
Can Opener	100	.00007	--minute
Carving Knife	92	.0003	--5 minutes
Clock	2	.06	--month
Coffee Maker	850	.0058	--10 minutes
Cooker (Egg)	516	.0017	--5 minutes
Curling Iron	40	.0004	--15 minutes
Corn Popper	575	.006	--15 minutes
Deep Fat Fryer	1500	.038	--hour
Dehumidifier	240	.0097	--hour
Dishwasher	1200	.029	--normal cycle
Disposer	420	.0003	--minute
Dryer	5000		
Regular Fabrics		.17	--load
Permanent Press		.13	--load
Electrostatic Cleaner	50	1.50	--month (continuous fan operation)

FIGURE 2.1

Electric Heating**			
Heat Pump (January Average)	15000	.105*	--hour
Baseboard (January Average)	15000	.138*	--hour
Furnace (January Average)	15000	.159*	--hour
Fans			
Attic	375	.0151	--hour
Circulating	88	.0037	--hour
Exhaust - small	200	.0083	--hour
Furnace (1/3 h.p.)	330	.0096	--hour
Rollabout	171	.0070	--hour
Window	200	.0086	--hour
Floor Waxer/Cleaner	350	.0145	--hour
Fondue/Chafing Dish	800	.016*	--hour
Freezer (15 cu. ft.)	341	4.35*	--month
Frostless (15 cu. ft.)	440	6.10*	--month
Fry Pan	1150	.03*	--hour
Garden Tools			
Edger	190	.0039	--30 minutes
Hedge Trimmer	265	.0055	--30 minutes
Garage Door Opener	350	.00024	--minute
Grinder (Food or Coffee)	150	.001	--10 minutes
Griddle	1200	.019*	--30 minutes
Hair Clipper	10	.00007	--10 minutes
Hair Dryer			
Soft Bonnet	400	.0166	--hour
Hard Bonnet	900	.0374	--hour
Hand Held	600	.0249	--hour
Hair Rollers	350	.0036	--15 minutes
Heat Lamp	250	.0104	--hour
Heating Pad	65	.0015*	--hour
Hi-Fi/Stereo	100	.00415	--hour
Hot Plate	1250	.026	--30 minutes
Humidifier	175	.02	--day
Ice Cream Freezer	130	.004	--45 minutes
Ice Crusher	120	.00041	--5 minutes
Iron	1000	.0228*	--hour

FIGURE 2.1 (CONT)

JUICER	90	.00006	--MINUTE
KNIFE SHARPENER	100	.00035	--5 MINUTES
LIGHTS*** - 100-WATT BULB	100	.0415	--10 HOURS
MAKE-UP MIRROR	25	.00026	--15 MINUTES
MICROWAVE OVEN	1500	.005	--5 MINUTES
MIXER			
HAND	100	.0021	--30 MINUTES
STANDING	150	.0031	--30 MINUTES
MOTORS****			
1/6 H.P.	170	.0004	--5 MINUTES
1/4 H.P.	250	.0006	--5 MINUTES
1/3 H.P.	330	.0008	--5 MINUTES
1/2 H.P.	500	.0012	--5 MINUTES
1 H.P.	1000	.0024	--5 MINUTES
POWER TOOLS			
DRILL (1/4 INCH)	240	.0009	--5 MINUTES
JIG SAW	370	.00128	--5 MINUTES
RADIO	75	.0031	--HOUR
RANGE			
SMALL SURFACE UNIT	1300	.015	--15 MINUTES (HIGH HEAT)
LARGE SURFACE UNIT	2400	.009	--5 MINUTES (HIGH HEAT)
OVEN (NON-SELF-CLEANING)	3200	.043*	--HOUR
(SELF-CLEANING)	3200	.034*	--HOUR
BROILER UNIT	3600	.037	--15 MINUTES
SELF-CLEANING FEATURE	4000	.15-.25*	--2 HOURS
REFRIGERATOR/FREEZER (14 CU. FT.)	330	4.16*	--MONTH
FROSTLESS	615	6.35*	--MONTH
ROASTER	1350	.034*	--HOUR
SEWING MACHINE	75	.0031	--HOUR
SHAVER	14	.00005	--5 MINUTES
SHAVING CREAM DISPENSER (HEATED)	60	.00004	--MINUTE

FIGURE 2.1 (CONT)

Slow Cooker - Low	75	.0031	--hour
High	150	.0062	--hour
Space Heater	1300	.054	--hour
Sump Pump (1/3 h.p.)	330	.0096	--hour
Sun Lamp	250	.0017	--10 minutes
Television			
Black & White	160	.0066	--hour
Solid State	55	.0023	--hour
Color	300	.013	--hour
Solid State	200	.0083	--hour
Toaster	1200	.0016	--2 minutes
Toothbrush	7	.000005	--minute
Trash Compactor	400	.0014	--5 minutes
Vacuum Cleaner	650	.027	--hour
Vaporizer			
Cool Mist	60	.0025	--hour
Steam	480	.0200	--hour
Waffle Iron	1200	.02*	--30 minutes
Warming Tray	140	.006	--hour
Washing Machine (Automatic)	500	.011	--normal load
Water Heater (Quick (Recovery)	4500	.10-.20	--per person/day
Yard or Post Lights			
175w Mercury (Bulb & Ballast)	196	.09	--night
100w Incandescent (Both based on photo-cell control--normal operating hours for one year -- 4,000)	100	.05	--night

Note: Costs exclude 3% sales tax.

* Thermostatically controlled. Cost based upon estimated percentage of "On" time.

FIGURE 2.1 (CONT)

**ELECTRIC HEATING AND CENTRAL AIR CONDITIONING COSTS VARY WITH EACH INDIVIDUAL HOME. MANY FACTORS ARE NEEDED TO ARRIVE AT AN ACCURATE ESTIMATE: SIZE OF HOME, TYPE OF SYSTEM, AMOUNT OF INSULATION, NUMBER OF DOORS, WINDOWS, ETC.

***MANY FACTORS AFFECT LIGHTING COSTS: SIZE OF THE HOME, TYPE OF LIGHTING, ETC. BUT KEEP IN MIND -- FLUORESCENT LIGHTS ARE MORE EFFICIENT AND MORE ECONOMICAL TO OPERATE.

****MOTORS FOR FURNACES, APPLIANCES, TOOLS, PUMPS, ETC. ARE RATED BY OUTPUT HORSEPOWER (H.P.), BUT DEPENDING ON SIZE, QUALITY AND LOAD CHARACTERISTICS THE WATTAGE RATING VARIES. IN GENERAL, 1 H.P. OUTPUT EQUALS 1000 WATTS INPUT AT FULL LOAD. HOWEVER, MOTORS ARE GENERALLY SIZED TO RUN AT 70% FULL LOAD.

FIGURE 2.1 (CONT)

GAS APPLIANCES

Gas Appliance	Typical Gas Input Rating CFH	Cost	
Air Conditioners**			
Central 3 ton	80	.140*	--hour
Central 5 ton	135	.235*	--hour
Dryer			
Regular Fabrics	25	.062*	--load
Permanent Press	18	.050*	--load
Furnace**			
(January Average)	137	.073*	--hour
Outdoor Grill (Full heat)	25	.0242	--30 minutes
Range			
Surface Unit	6	.001	--5 minutes
Oven	30	.030*	--hour
Water Heater	37	.05-.10	--per person/day
Yard Light	2	.092	--day

FIGURE 2.2

Note: Cost includes both gas and associated electrical energy use for appliances, but excludes 3% sales tax.

* Thermostatically controlled. Cost based upon estimated percentage of "On" time.

** Natural gas heating and air conditioning costs vary with each individual home. Many factors are needed to arrive at an accurate estimate: size of home, type of system, amount of insulation, number of doors, windows, etc.

the counter with the shortened distance is an energy-use optimum procedure.

Figure 2.3 gives the efficiency of energy conversion in the form of lumens/watt of power consumed. As can be seen, incandescent bulbs or lamps are the least efficient. The mercury, metal halide, and sodium lamps are the most efficient but require expensive fixtures and are not completely safe for indoor use.

When discussing illumination and lighting, one can learn that the intensity or light flux is inversely proportional to the square of the distance. This means that if a light has a unit of 100 in intensity, when one comes out one foot from that light, an area that is 1 foot by 1 foot square has one unit of density which will be set equal to 100. If one then comes out to a distance of 2 feet or 2 units, the light, because of the direct ray pattern shown in Figure 2.4 spread over an area which is 2 units by 2 units along the edge or 4 square units of intensity. This means that the intensity of the unit area is one-quarter the amount at 2 feet than it was at 1 foot. The exact constant of proportionality is experimentally determined and the measurement at 1 foot can be used to set its value arbitrarily. If one comes out 3 feet, then the same intensity is spread over an area of 3 feet or 3 units of size giving you 9 square units that are being illuminated by direct ray analysis. This means that the intensity per unit area has now dropped from 100 to 1/9 of 100 or approximately 1 .1%. Thus, indirect lighting and lighting at long distances from the working surface is dissipated with respect to proper lumen level by

LAMPS--EFFICIENCY

TYPE	LUMENS/WATT
Incandescent	8-22
Fluorescent	79
Mercury	30-65
Metal Halide	70-95
High-Pressure Sodium	110

FIGURE 2.3

the distance light has to travel and dispersion of the light rays as they travel toward the working surface.

Fluorescent lighting, because of its greater efficiency of approximately 40% with respect to converting electrical energy into illumination, is much more cost effective for general lighting purposes. However, fluorescent light without careful reflection or concentration is not useful for high intensity close work. Therefore, in these cases, an incandescent bulb which has approximately a 12% efficiency with respect to converting electricity into illumination is much more preferable for this type of work. Also, for general lighting where different levels are required for different activities, such as in a hallway to a living room, a kitchen or other room where at one time one wants illumination of a level applicable for either close work or reading, while at other times one wants back lighting for other purposes than reading, it is more advantageous to consider the use of a mixture of light fixtures, one must determine how much the different options are going to be used. If one's primary use is close spot work, then an incandescent bulb coupled with a rheostat for lowering intensity for back lighting cases could be the most energy efficient option. This would be both in respect to money invested and the needed power use.

ILLUMINATION

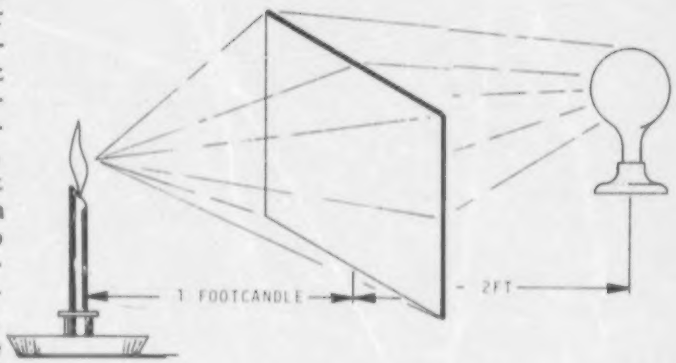

FIGURE 2.4

C. ENERGY CONSERVATION FOR CARS

In relation to cars, energy conservation can be separated into two parts. The first has to do with the efficiency of the car chosen, and the second with the way the car is handled, driven, and repaired. In general, the lighter a car is in weight and the lower the air drag and cross-sectional profile due to smaller size, the more energy efficient it will run for any fixed engine. Fifty pounds additional weight reduces mileage for large cars by about 1 mile per gallon of gasoline. The purpose of these modules is not to suggest that a particular type of car be bought, but that a person analyze needs and buy no more weight, size and energy-consuming options than are necessary. After the weight has been chosen, one should note that if a person will not carry a lot of extra weight in the car in the form of personal accumulation, slightly better gas mileage will be possible. In the second area, the way a person drives is, for any particular car, a major determination of whether it gets high or low gas mileage with respect to its EPA standard mileage rating. Mileage energy conservation tips are listed in the following paragraphs.

The second area related to energy conservation for automobiles is the importance of maintenance and use patterns. These two are considered together because when a car is used basically for city driving in which it is not allowed to reach temperatures necessary to dry out the exhaust system, or remove from the oil and crankcase the moisture depleted from the gasoline, sludge builds up in the oil. In this case, the oil filter should be changed more often to lengthen the lifetime of the car. Highway driving, or driving that allows the car to reach sufficient temperatures to dry out the exhaust system and to raise the temperature of the engine sufficiently to prohibit production of carbon, requires changing the oil and oil filter less often when compared to all city driving. The times and mileage suggestions for these oil changes and other preventive maintenance are given in manufacturer's manual provided for each make of car. Thus, maintenance should be coupled with normal driving patterns.

Driving patterns include two basic factors: those which have to do with the type of driving done, namely, local, highway, etc.; and individual driving habits. The second area is characteristically unique to each driver. For example, does the driver accelerate slowly and carefully, or have a tendency to change momentum or change velocity rapidly; are the brakes, clutch, or transmission used excessively; does the person jackrabbit or tend to do drag-race starts with the car, etc.? Any one of these approaches which involves a high acceleration or high change of velocity, momentum, or speed in a short period of time are activities or sudden changes in the car's operating mode which tend to mechanically over-torque the car's engine and rive train. These sudden spurts rapidly wear out a car and also use much more energy. Long-term driving patterns, to be energy efficient, must be consistent and must be essentially of a defensive driving nature in which one carefully plans move and uses a minimum amount of acceleration change and fast braking.

MODULE XI

ECONOMICS FOR ENERGY CONSERVATION

UNIT III

ENERGY CONSERVATION METHODS AND TRADE-OFFS

UNIT OBJECTIVES

1. Discuss two methods of energy conservation as trade-offs:
    a. Reduction of unnecessary use.
    b. Planned usage to reduce peak demands.
2. Identify trade-offs in utilizing heating and cooling equipment.
3. Identify energy conservation methods in heating and cooling equipment and operation.

MODULE XI

ECONOMICS FOR ENERGY CONSERVATION

UNIT III

ENERGY CONSERVATION METHODS AND TRADE-OFFS

LECTURE	ACTIVITIES
An individual, when making a decision to engage in using the principles of energy conservation, must know more than a little about the methods and trade-offs involved. One should be aware that not only is the direct use of energy in the form of lighting, heating, and cooking to be considered, but also the other energy costs that are represented by the provision or supply of hot water, water pressure, water purification, maintenance of lawns, external lighting, etc., must be included in any detailed reasonable energy-accounting scheme. Energy conservation methods consist of two major types: (1) reduction of unnecessary use, and (2) planned usage to reduce peak demands. The following energy conservation methods listed and their trade-offs will in many cases fall into both areas. For any particular appliance or activity, conservation methods will reduce demand of energy necessary to operate that particular appliance. However, by shifting or limiting the number of appliances being used at any particular time or time sequence, one can determine the individual demand being made on the utility energy system. Let us first consider energy conservation methods that have to do with heating and cooling.	

A. HEATING AND COOLING--TRADE-OFFS

Using climatic data from previous modules, the rough determination of optimum heating and cooling loads for the local area can be calculated and discussed. Using this data, one can determine the heating degree-days or cooling degree-days on a mean value for a particular location. A heating degree-day is defined in order to give a rough approximation of the expected heating power demand required as a function of mean hourly, daily, or monthly temperatures. The heating degree-day is defined on a base of 65°F for any mean predefined value or unit of time; by definition the heating degree-day value is zero. However, if the temperature should be at a value of 64°F for a day or other defined interval, then that day (or interval) is one heating degree-day given in °F days or other time units, if the interval considered is shorter than a day. If the temperature is 60°F on a particular day, as a mean value, then for that day the value is 5°F days or 5 heating degree-days. This means that if the temperature is 64°F for five days, then there are five heating degree-days. The heating load is determined by multiplying the number of degrees below 65 times the number of days for each particular temperature, and then summing these up for a specified period of time. If, however, the temperature is 60°F for one day, this again (the number of degrees below 65°F times the number of days) gives 5°F days for the value for the measured heating load. This says in a mean degree value that the amount of energy necessary to heat a house from 64°F to

65°F on five days is equal to the amount of energy necessary to heat the same house from 60°F to 65°F for one day.

Originally, the heating degree-day reference temperature was 70°F, and, in some places, higher. Therefore, one can see that by allowing the mean heating degree-day reference temperature of 65°F to be lowered to 60°F, the energy crisis and need for many parts of the southern U.S. can be defined away. However, this could be a political and not a health decision. Under these conditions (60°F heating temperature for interval living spaces), the comfort index will be reduced to a marginal level, but an absolute power demand can be calculated. However, if one decides to raise the cooling degree reference temperature from 70°F to 75°F or 78°F, then the consequences are not as great with respect to the comfort index. In regions where the humidity is low, as was discussed in Module IX, the comfort index is so defined that it measures human body comfort. Therefore, in regions that are quite dry, higher temperatures of 80°F to 90°F are as comfortable as is 70°F with 40-70% humidity. An example of this in the desert southwestern United States where, with a 5-10% relative humidity level, a temperature of 100°F feels like approximately 70°F with 60% relative humidity as far as human body comfort is concerned. However, the individual will notice that it is necessary to drink more liquids, because the body is perspiring and high levels of evaporation are working to cool the body. If energy conservation with human comfort are the only criterias, then one can allow the temperature of the

Students should be involved in exercises of this nature to find out what the expected savings would be by using energy conservation molds in their particular house by manual setting of the thermostats. The principles of heating and cooling systems are discussed in Module X. The actual principle behind the systems does not have to be understood in complete detail to do conservation analysis.

conditioned space in the hot-day regions of west Texas to raise greatly and still be quite comfortable with respect to the cooling degree reference temperature. As energy conservation becomes a major problem in this country, local comfort indexing of the temperature of the local climatology, and mainly of the daily values of the local relative humidity, should be seriously considered.

The other concept is the cooling degree-day which is currently defined as a measure of the number of degrees times the number of days that the mean temperature is above 70°F. In a similar manner to the heating degree-day definition, if the temperature is below 70°F on a mean value, by definition there is no cooling degree-day value, or the cooling degree-day value is zero. If the temperature is 71°F for one day, then for that day, again the cooling degree-day value is 1°F day. If the temperature is 80°F for one day, then its 10°F times 1 day for 10 cooling degree days. Again, the cooling degree-days for 1 day with an 80°F temperature and 5 days with a 72°F temperature are roughly equivalent for this type of general calculation. This obviously is not always directly true since the heat flow is a gradient function and a function of the temperature gradient per unit length and thus is a function of the temperature difference across the surfaces through which the heat is flowing. Calculating using the accuracy available in heating degree-day information provides a good baseline tool for "back-of-the-envelope" type calculations. These calculations can be used to determine within 10-15% what the expected power consumption will be for any particular building during the time defined by any particular period for which the degree-day load has been calculated. It should be noted that the results from a mean cooling degree-day for a day when the temperature reaches 80°F can be calculated using mean hourly, mean daily, or (if someone wants high precision), mean minutely or quarter-hourly, data to calculate this quantity. The instructor should take representative data and show how one calculates heating and cooling degree-days. Obviously, the more mean data used, the more information about direct gains and losses are averaged out of the system. Thermal time constants, thermal inertia, and thermal mass become important in determining whether the information lost by use of these simple calculation methods will add to the temperature swing or uncertainty in the building.

B. ENERGY HEATING AND COOLING--CONSERVATION METHODS

In order to talk about energy conservation methods for heating and cooling, one must first consider the characteristics of the system with which one is dealing. The internal area of the home under the control of the heating, ventilating, and air conditioning system is the conditioned space of the building. The temperature can be maintained within this conditioned space by use of a number of possible systems or methods which include mechanical, active, passive, natural, and/or artificial. Any of these methods can be used to maintain the desired temperature and comfort index. The comfort index and comfort zone were discussed in previous modules.

An energy demand audit should be done on the house of the student or on the typical house that will be included in the material. A student is to look at the house, the way the walls are constructed to determine how many square feet there are of each wall type and the approximate wall construction R and U values discussed in Module VIII. Then, they can calculate the expected heat loss or heat gain for that house for winter and summer use, assuming no direct solar gain. Direct solar gain activities are discussed in Module related to energy conservation methods and trade-offs are to be used to determine solar gain component of the picture. This should be used as a separate item to be either added or subtracted depending on whether the temperature desired inside the conditioned space is hotter or colder than its surroundings. Calculations of R and U values for the house as it now is, and after the addition of more insulation, storm windows, and other heat flow inhibitors should be done before any changes are made to determine costs and benefits.

Within the conditioned space itself, there are three effects that must be understood in order to look at different methods for handling and producing energy demands.

In general, for any objects above absolute zero, energy is transferred from a hotter surface to a colder surface by any one of a number of energy transfer mechanisms. These mechanisms are:

1. radiation
2. conduction
3. convection
4. forced convection

Radiation, which is the mechanism whereby the solar energy is transmitted by the sun to the earth, is the result of energy being radiated from one body to another. The radiation laws are known as Stefan-Boltzemann Laws which say the flux per unit area is directly proportional to the temperature to the fourth power. All generation techniques and methods are based on reducing the power needed to maintain a system by reducing the losses and gains from the conditioned space to the surroundings. These losses are reduced by the reduction in the three forms of energy transfer mechanisms. These energy transfers or heat conduction methods have been discussed in previous modules.

Human comfort in any particular area is a result of the loss from the skin compared to the amount of heat internally generated within the body. This means any one of a number of methods, including clothing, higher temperature air, materials and radiant heaters, etc., can be used to maintain body comfort. When the human body at its higher temperature is radiating more heat to an unprotected or unshielded lower external temperature, the body loses heat. The amount of heat lost depends upon the temperature difference, the number of heat-loss retarding clothing layers, and the activity level of the individual. Therefore, the comfort region for activities is much different than that for at rest. This means that in general a person should look at the activities to be carried out at the time of day, etc., to determine what temperature should be maintained within the conditioned space. Personal preferences should also be considered at this point. But it should be noted that it is easier and much less expensive to wear sweaters, heavier clothing, and multiple clothing layers than to heat a complete building. Using the principles of clothing discussed in other modules, it should be obvious that what a person is doing is making a microclimatology around him/herself by the process of putting on clothing layers for the purpose of trapping the heated air at the surface of the body, or by reducing the needed cooling levels by letting body heat escape or by controlling the rate at which the heat or hot air is lost. The comfort index or the comfort ratio can be adjusted according to season, activity, and individual need. Let us list a number of energy conservation methods which can be used to reduce the energy costing in a particular building.

1. Controlled infiltration rates--Infiltration is defined as the rate of air flow into or out of a structure. This air

flow is caused by pressure differences, wind, breeze, and opening and closing of doors, vents and windows in the building. Minimum infiltration levels are required in most building codes. However, most buildings, especially houses, have much higher infiltration rates than are required. One of the major causes of infiltration is the fact that house air is burned in the furnace and exhausted through the vent or flue. This leads to a pressure difference of a few pounds per square inch. However, this pressure difference has enough force, if contained, to raise a 2- to 3-inch concrete slab. Thus, a slight pressure difference provides a terrific drive gradient to force air through the walls of the building and into the house. This means spending a large amount of fuel dollars in heating outside air which then goes up the chimney. The air enters through cracks around doors, through window facings, and through any place in the building which is not airtight. If one wants to reduce infiltration rates, one of the easiest methods is to fit a furnace which is in the conditioned area of the house to draw its burning air from the outside. However, this type of modification should be done by a licensed heating, ventilating, air conditioning contractor. When infiltration rates have been reduced by removal of the furnace pressure difference, by caulking, by installing storm windows, by sealing the house, and controlling the wind pressures, infiltration rate can be controlled by the use of the exhaust fans to meet the necessary comfort levels.

2. Controlled direct gain rates--Direct gain is an advantage in the winter and a disadvantage in the summer with respect to the heat load on the building. Direct gain is by heat that penetrates walls and radiates into the room, plus that which comes through the windows, which is absorbed in the internal surfaces, and reradiated into the structure. The direct gain through the walls is more commonly known as thermal time lag. This method was the basis for adobe and Pueblo Indian construction in the southwestern United States. For massive walls of adobe, the temperature time constant is such that in the evening when the atmosphere cools off in the desert southwest, the heat that has been entering the walls due to the direct solar illumination and from the hot air warmed with solar energy is absorbed as heat into the wall, raising the internal temperature. The time constant for thick adobe walls is such that the remnants of this absorbed heat, not dissipated in the wall mass, have now reached the inside, radiating into the rooms to warm them. Traditional direct gain is defined as energy coming through the window which is absorbed in the inside of the structure. Obviously, this is an advantage in the winter and a disadvantage in the summer. Therefore, one should reduce the direct gain during the day in summer by insulating shades, awnings, etc. Also, at night in winter, the direct gain or the convective and radiative losses can be reduced by using some sort of insulated shutter. Direct gain, however, has one disadvantage: the ultraviolet in sunlight fades colors, breaks down fabrics, and causes disintegration of many upholstery and furnishing fibers.

3. Controlled conductive losses through the walls or through thermally transparent surfaces--Standard insulation techniques for walls and ceilings are discussed in Module VIII. These methods should be applied in conjunction with storm windows and storm doors. Attic insulation should, in general, be added first. The savings to be realized by insulation, storm windows, etc., will be discussed in a later unit. One can control the conductive loss through a thermally transparent surface by the use of storm windows, insulated shades, and the use of moveable insulation in the form of bead walls, shutters, and related types of materials. The important thing with controlling those conductive losses thorough thermally transparent surfaces is that when the temperature gradient is in the wrong direction with respect to the conditioned space, one reduces the conduction by increasing the insulation or the R value of the materials so that less heat flows through the thermally transparent surface which is predominantly window glass. Glazing materials in general have very low R values and thus contribute to high heat losses or gains, depending on the season. Thus, with the proper control of the insulation over glazings, in summer the heat is kept out and the cold is kept in, and in winter the cold is kept out and the heat is kept in. The amount of savings depends on where one is located in the country. The moveable thermal barriers or moveable insulation are essentially closed in the daytime in winter and closed at night. This assumes, of course, that one is not concerned about the other problems discussed with respect to solar ultraviolet radiation and its affect on furnishings.

4. Increase the thermal mass and thermal inertia of the walls by installing insulation, either in the form of mass or reflective insulation. This change in thermal time characteristics is a different effect from strictly the R value insulation effects. These are dynamic effects and must be determined using U values.

5. Adjust overall infiltration surges and pulses by the use of air locks--Rooms on both ends of the house, such as an enclosed vestibule with paired doors, or utility room with paired doors, can be used to reduce the overall infiltration surges and pulses. This is done with the air locks or double-doored vestibules and rooms installed, by the simple process of entering the room or area and closing the outer door before opening the inner door, and doing the reverse when leaving. These rooms are in general not heated or cooled to the temperature of the rest of the house, and may have no direct heating or cooling except when required by climatic constraints and extremes. The heating would be required only if there are present such things are water pipes in utility rooms or other types of material which might freeze. This restricted heating, cooling, or conditioning of space means that less energy is used to maintain this space at a minimum level and that the temperature gradient between this space and the outside world is less. Therefore, when one opens the door to leave or enter, the shock or surge or pulse on the conditioned space of the inside of the rest of the house is much less and is controlled by the volume of the room, and in all

cases is much less in temperature and amount to that which would be the case if the outside door was opened directly. This is especially important for high temperature differences, high humidity differences in the case of cooling, and for cases where there are high winds.

6. Water Heaters--Temperature reductions on a water heater save significant amounts of energy. If one is repiping a house, a small-piped high pressure system will also reduce heat losses. One should wrap and insulate both the hot water pipes and the water heaters; also to save energy one should reduce the settings of the control thermostat, temperatures from 150°F to 130-135°F. This, coupled with insulating the water heater, can save 35-40% of the bill compared to the bill for the higher temperature and no insulation. When a person is to be away for more than two days, the water heater should be turned down to pilot or OFF if it has an electric ignition. The energy needed to reheat the water tank after returning will be less than the energy required to maintain temperature while the house is empty. In general, the heat from an electric water heater and other appliances such as small furnaces, dryers, stoves, etc., should be vented out in summer, and captured in winter to reduce conditioning costs.

7. Plan meals in an organized manner and use leftover pre-planning to reduce the amount of food that needs to be cooked. Alternative use of ovens and countertop appliances can reduce cooking energy demands. Consider microwave ovens for small energy use products.

Stovetop appliances and countertop appliances are most useful for special jobs. Consider pressure cookers as an option in preparing food.

8. Dishwashers--Drying cycles in dishwashers can be eliminated, rewired to off switches and saved for special cases, or machines can be purchased with energy-saving controls so that when it's necessary to heat dishes or to dry in a hurry under crash situations, the option is still available. In general, air-drying of dishes, pots and pans, etc., is much more sanitary and certainly uses a lot less energy, either in the form of drying in the dishwasher or the washing and drying of dishtowels.

9. Use more recyclable materials such as cloth dishcloths, dishtowels, rags, etc., instead of paper and other products. Even though the paper itself is a renewable resource, much energy is spent in processing it and removing the pollution products from the effluents which have to be discarded.

10. Reduce the flow of toilets to what is minimally necessary by separate partitions, etc. These partitions will save water and thus energy not only on the front end with respect to purification, but also with respect to processing of sewerage, both of which consume energy.

11. Zonal living should be considered as an option for the peak energy conditioning power demand months. House organization should be structured to take advantage of siting internal use, possible renovation, and energy lowest reduction as well as positioning current utilities and other heat sources.

12. It should be noted in general that vegetation layers against building surface walls do effectively increase the resistance of that wall to thermal losses. These are done basically by decreasing the sensitiveness of the boundary layer of the wall to temperature changes due to breezes and solar heating. Changes in the temperature of the air in the boundary layer of the wall with changes in the external environment will determine the temperature difference and thus heat flow through the wall. One wishes to reduce or control the detrimental extremes in the boundary layers. These changes are predominantly in temperature and velocity, though they can include radiation enhancement or heating. Therefore, the bushes should be allowed to grow as high as possible and cover as much of the wall as possible, especially on the north, and on the west and south sides of the building where one wishes to reduce heating load in summer from the sun, and cooling of the structure in winter by winds.

Lawn maintenance should also be analyzed to minimize the time and energy involved, though this will be hopefully a minor improvement. While equipment such as power mowers, etc., are running, they are consuming energy. Therefore, cutting patterns which are involved or plantings which involve a large amount of specialized cutting, backing, and turning should be avoided if one's main criteria is energy conservation. It should be noted that when one has a one-story house with a ground-level slab, the trimmings from the lawn and from the leaves from the trees can be used to mulch under shrubbery against the house, and thus help isolate the slab and near surrounding ground from temperature stresses due to diurnal changes of temperature. It should be noted that the slab itself should be insulated, using appropriate insulation materials, but if one has mulch under shrubs, and maintains this for a fair distance out from the building, then this will insure that the ground will not heat or freeze right up to the building. It should also be noted that the temperature difference will be over a larger length and thus the gradient, the driving force of heat flow, will be reduced. Also, the ground around the building heats with the sun impending on the bare surface. Not only does this heat the ground in the summer and thus heat the area under the foundation, but is also helps dry the soil. In some regions, to help maintain stability and position of the slab, additional watering will be required since mulch not only maintains the ground as cool but it also maintains water levels. Thus, in both cases the transpiration rates are reduced and the watering requirements are minimized. Along the lines of maintenance, it should be noted that watered lawns which are maintained at grass heights which are at or near the upper level of the optimum length of a region will, in general, require less watering to maintain during times of stress. It is the cutting of the leaf of the grass which is the most stressful activity on the plant, and when one cuts grass short and frequently, more water is necessary to insure proper recovery and new growth. Also, short cutting will expose more of the ground area, increasing the amount of transpiration.

13. Attic wind turbines, wind fans, natural convection, thermal chimneys, etc.--These items are used generally to ventilate attics and not to move air. The purpose of an attic is to remove the heat generated by the solar intensity beating on the roof, and of the living space, by providing a thermal barrier which is readily accessible or exhaustible, and thus reduce the heat flow into the living space. The naked or insulated unfinished attic provides thermal insulation, but in southern climates and moderate mid-latitude climates, it is not uncommon for an attic to reach 120°F on a moderately warm day when the external temperature is less than 90°F. This means that if one is conditioning the internal space at 75°F, there is a 45°F temperature difference across the ceiling. The temperature gradient determines the heat flow; therefore, a high gradient in temperature will produce a high heat flow. If one exhausts the attic by use of one of the above devices (preferably window turbines, wind fans, or properly sized thermal chimneys) to move enough air to stratify the temperature in the attic, then the temperature at the floor of the attic or ceiling of the living space is reduced and the heat flow also reduced. This means that the temperature at the peak or top of the attic will reach 115-120°F, but at ceiling level, because the vents are located in this region, the temperature is only about 80°F, or approximately 5-10°F above outside temperature, which is higher. This stratification means that the temperature difference is now only that between the inside and outside temperature, plus a 5-10°F boost. Thus, heat flow into the room through the ceiling is reduced.

14. Space heaters--Space heaters generally are very inefficient heating sources when applied to large areas. However, for zonal heating or pre-heating of bathing or dressing areas when the rest of the house is maintained at a lower temperature level, a space heater can provide local temperature improvement and comfort. Optimum use of these space heaters can greatly reduce overall energy use when one is trying to conserve by zonal living and manual overriding on the temperature adjustments. However, space units do not replace conventional heating and cooling units.

MODULE XI

ECONOMICS FOR ENERGY CONSERVATION

UNIT IV

ENERGY COSTING AND ACCOUNTING

UNIT OBJECTIVES

1. Determine energy costs versus efficiency of operation for appliances.
2. Determine cost investment and savings for insulation materials.
3. Determine payback periods for conservation measures as opposed to various types of conventional fossil fuels for heating.
4. Determine and prioritize retrofit measures for energy conservation in the home.

MODULE XI

ECONOMICS FOR ENERGY CONSERVATION

UNIT IV

ENERGY COSTING AND ACCOUNTING

LECTURE | ACTIVITIES

A. COST FOR INSULATION

The current cost of energy consists of both the current costs of running an appliance or a facility, plus the capital costs of producing and installing the item. This is particularly important with respect to energy conservation and retrofit costs for housing, namely, insulation, storm windows, etc. With respect to the projected growth in energy costs, the amount of money to be spent will increase with time as these energy costs increase. The capital cost of a particular appliance must be considered along with the lifetime energy cost to determine how effective the saving will be on a particular appliance or energy-using item. This means that if a person buys a refrigerator for $300, which in its lifetime uses $1,600 worth of electricity, a saving can be made even if the money must be borrowed at current interest rates, than if someone buys a $400 refrigerator which in its expected lifetime of approximately 16 years, the cost of electricity lies between $1,000 and $1,200. This $400-$600 energy savings, possible over the lifetime of the appliance, will more than pay for borrowing the extra $100 to buy the more efficient appliance. Therefore, a person needs to do calculations on the wattage and energy use to determine how much it is going to cost to use a particular item or appliance.

The data from the other modules, including meter readings, how to read an electric or gas appliance tag, and how to determine bills for electric and gas usage are directly applicable to the study of this problem.

Using the information on R and U values for various materials, persons should calculate on baseline data the present heating and cooling loads for their homes. The exact methods for these calculations have been done previously. After the basic R and U values equivalent has been determined for various segments of the building, one can either calculate the loads as a function of specific months or seasons, using mean heating or cooling degree days. This information provides a basis for the current load values for the house. One then determines the Btu load for the structure for monthly and design degree-days for both the heating and cooling season. Using the calculated Btu data for the house, one can then determine the amount of energy needed and the cost. One first much convert the energy needed into power requirements using the equipment efficiencies. This will give one a measure of the Btu totals needed to provide the BTUH values or Btu sums required to satisfy the heating or cooling load. Dividing by the heat content of the fuel will give one a measure of the amount of energy needed in the form of fuel to maintain comfort conditions. Multiplying the result of the current cost of utility fuel units, coupled with base rates and maintenance costs, will give one (assuming calculations are all correct) current utility bill totals. One needs to include both base rate changes and fuel adjustment costs in determining current utility rates per unit of energy delivered.

In order to determine the saving for a particular energy conservation package, the R value changes to the house must be determined and the new fuel needs determined. These calculated fuel savings, compared to the total cost of the improvement (materials, labor, capital, and interest), will determine the payback period for the improvement. A set of payback periods in terms of years for energy conservation systems as considered for Dallas, Texas at 1977 utility prices are presented as a function of utility type for the most common forms of retrofit systems.

A detailed analysis of the energy conservation options as a function of most cost-effective have been made for most of Texas, exclusive of the Panhandle. As a result of this analysis, a two-part retrofit package has been developed. These are a series of steps which can be taken for the most cost-effective energy conservation steps one can take to reduce energy bills. These are presented in Figure 4.1A, the basic package, and Figure 4.1B, the better package. If one is going to pay for all work to be done by outsiders, do the basic package first. If the homeowner can do the work, then all items in both Figures that they can do should be done first. Figure 4.3 shows the payback period for these energy conservation measures.

Typical annual energy use patterns for various types of residences are shown in Figure 4.4. These average patterns should be used for comparative purposes in the activities and experiments discussed in this module. Taking these annual energy use patterns and multiplying by the average cost of power as shown in Figure 4.4 , one gets the average monthly bills in roughly 1977-79 dollars.

There are several national energy conservation analysis and payback programs. One is TEXAS CONSERVE, P.O. Box 4965, Austin, Texas 78765. TEXAS CONSERVE provides access to a nationally developed computer program to calculate potential savings, or payback, from specific energy conservation actions. Energy payback calculations tell how long it takes different home energy conservation measures--like insulation, caulking, and storm windows--to pay for themselves in lower home utility costs. The instructor should write for these questionnaires for class use.

RETROFIT PACKAGE

TEXAS--EXCLUSIVE OF PANHANDLE

BASIC PACKAGE

INSTALL DAY/NIGHT CLOCK THERMOSTAT

ADD CEILING INSULATION TO ACHIEVE TOTAL OF APPROXIMATELY R-19

TUNE-UP FURNACE AND AIR CONDITIONING SYSTEM

WEATHERSTRIP EXTERIOR DOORS

SEAL ALL OPENINGS AND CRACKS IN EXTERIOR WALLS

CALIBRATE WATER HEATER TEMPERATURE

WEATHERSTRIP AND INSULATE ATTIC ACCESS DOOR

INSPECTION OF ENTIRE HOUSE FOR ADDITIONAL RECOMMENDATIONS

FIGURE 4.1

RETROFIT PACKAGE

TEXAS--EXCLUSIVE OF PANHANDLE

BETTER PACKAGE

ADD CEILING INSULATION TO ACHIEVE TOTAL OF APPROXIMATELY R-22

INSTALL R-11 FLOOR INSULATION ABOVE UNCONDITIONED SPACES

TAPE DUCT JOINTS AND INSULATE DUCTS IN UNCONDITIONED SPACES

INSTALL STORM WINDOWS IN ALL LIVING AREAS

BLOW INSULATION IN UNINSULATED EXTERIOR WALL CAVITIES

ADD OR INCREASE NATURAL ATTIC VENTILATION, IF NECESSARY

INSTALL CEILING FAN FOR SUMMER COOLING

FIGURE 4.2

PAYBACK PERIODS FOR RETROFIT ENERGY CONSERVATION SYSTEMS FOR DALLAS, TEXAS (1977)

	TIME IN YEARS			
TYPE OF WORK	HEAT PUMP	ELECTRIC RESISTANCE	GAS	OIL
ADD STORM SASH	12	7	16	6
ADD 6" INSULATION TO UNINSULATED ATTIC	3	2	3	2
INCREASE 3 1/2" INSULATION IN ATTIC TO 6"	7	5	8	5
BLOW 3 1/2" INTO SIDEWALLS	12	8	14	8

FIGURE 4.3

TYPICAL ANNUAL ENERGY USE PATTERNS
VARIOUS RESIDENTIAL CUSTOMERS

(ALL FIGURES IN KWH, EXCEPT FOR GAS APPLIANCES AS NOTED)

APPLIANCES NORMALLY IN USE	APARTMENT	SMALL HOME	AVERAGE HOME	LARGE HOME	ALL ELECTRIC HOME
COMFORT CONDITIONING INCLUDING:					
AIR CONDITIONER					
ROOM	650	1,389	2,100		--
CENTRAL	--	--	--	3,200	2,650
HEATING					
FURNACE - GAS (CCF)	(C.M.)[1]	(960)	(1,250)	(1,895)	--
FURNACE MOTOR	--	400	600	1,500	400[2]
ELECTRIC BASEBOARD	--	--	--	--	20,400
ELECTRIC AIR CLEANER	--	--	--	216	216
ATTIC FAN	--	--	--	291	--
WINDOW FAN	--	170	170	170	170
DEHUMIDIFIER	--	--	--	377	377
HUMIDIFIER	--	113	163	213	163
HEATING PAD	10	10	10	10	10
ELECTRIC BLANKET	--	147	147	147	147
TOTAL COMFORT CONDITIONING:	660	2,229	3,290	6,124	24,533
APPLIANCES:					
RANGE					
ELECTRIC	--	22[3]	900	900	300[4]
GAS (CCF)	(C.M.)[1]	(90)	--	--	--

FIGURE 4.4

APPLIANCES NORMALLY IN USE	APARTMENT	SMALL HOME	AVERAGE HOME	LARGE HOME	ALL ELECTRIC HOME
Laundry:					
Wringer Washer	--	76	--	--	--
Automatic Washer	--	--	103	103	103
Dryer					
Electric	--	100^3	100^3	993	993
Gas - with pilot (Ccf)	--	(65)	--	--	--
Gas - electric ignition (Ccf)	--	--	(45)	--	--
Iron	144	144	144	144	144
Water Heater					
Electric	--	--	--	--	4,800
Gas (Ccf)	(C.M.)	(325)	(325)	(325)	--
Total Laundry	144	320	347	1,240	6,040
Entertainment:					
Radio(s)	86	86	172	172	172
Stereo	--	109	109	109	109
T.V. (B&W)	--	--	362	362	362
T.V. (color)	502	502	502	502	502
Total Entertainment	588	697	1,145	1,145	1,145

FIGURE 4.4

APPLIANCES NORMALLY IN USE	APARTMENT	SMALL HOME	AVERAGE HOME	LARGE HOME	ALL ELECTRIC HOME
MICROWAVE OVEN	--	--	--	--	300
DISHWASHER	363	--	363	363	363
TOASTER	39	39	39	39	39
MIXER	13	13	13	13	13
COFFEE MAKER	106	106	106	106	106
BLENDER	--	--	15	15	15
DISPOSAL	--	--	30	30	30
HOTPLATE	90	90	--	--	--
FRYING PAN	--	186	186	186	186
BROILER	--	--	--	100	100
DEEP FRYER	--	83	83	83	83
WAFFLE IRON	--	22	22	22	22
TRASH COMPACTOR	--	--	--	50	50
SANDWICH GRILL	--	--	--	33	33
ROASTER	--	--	250	205	205
CARVING KNIFE	--	--	3	3	3
TOTAL APPLIANCES:	611	539	1,965	2,148	1,84[illegible]
FOOD PRESERVATION:					
REFRIGERATOR					
12 CU. FT.	728	--	--	--	--
14 CU. FT. - FROSTLESS	--	1,829	1,829	1,829	1,829
FREEZER					
15 CU. FT. - FROSTLESS	--	--	--	1,761	1,761
TOTAL FOOD PRESERVATION	728	1,829	1,829	3,590	3,590

FIGURE 4.4

ENERGY COSTS AND EFFICIENCY OF CONVERSION

I) HEAT CONTENT OF FUELS

ELECTRICITY	3412 BTU/KWHR
NATURAL GAS	1050 BTU/FT^3
COAL	1310 BTU/GAL.
OIL	141,000 BTU/GAL.

II) EQUIPMENT EFFICIENCIES

	RECOMMENDED NEW	USUAL & AVERAGE	IF KNOWN
A) COOLING			
(1) ELECTRIC	2.05	1.47	EER/3.412
(2) GAS ABSORPTION	.48	.27	COP
B) HEATING			
(1) ELECTRIC RESISTANCE	1	1	1
(2) ELECTRIC HEAT PUMP	2.25	2.25	SEASONAL PERFORMANCE
(3) FURNACE (GAS)	.75	.55	EFFICIENCY

FIGURE 4.5

B. DEVELOPING YOUR OWN ENERGY CONSERVATION PRIORITIES

Energy conservation, to be effective in any group--national, regional, local, or an individual home--must be based on a consensus and a compatibility with the desired lifestyle. Therefore, before an energy conservation plan can be put into use, it must be prioritized and indexed with respect to individual wants. Out of this prioritizing and indexing procedure should come two lists. These lists should consist of all energy conservation options that are seen available to the group, considering the possibility of reducing utility costs. The first list should have all desired or current activities in order of increasing importance to the individuals concerned with reducing or controlling their energy use. Namely, the items at the top of the list are those activities or energy uses which are least important and would be least likely to be missed if reduced or eliminated. The second list should catalog, in descending order from the highest to the lowest energy use, the activities in which the group or individual is currently engaged. This second list should then be modified to consider which of the high energy uses are more viable to the maximum reduction in energy costs, while at the same time modifying with a limited impact the desired activities at the bottom of the first list. Obviously, all activities should appear on both lists. The first list (which will be called the List of Luxuries) will have the most luxurious at the top and the least luxurious at the bottom. Those items which can be most readily eliminated would be at

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the top of this list. The second list will be the List of Ranking Energy Uses in that lifestyle. The second list is important for two reasons: (1) it tells which areas are large energy users, and (2) it shows which of these can be reduced with minimum cost. For example, if Item 1 on the Luxury list is a totally frivolous item, which is of no importance to the household standard of living, then it is readily eliminatable. Such things as electric can openers, motorized corkscrew and bottle cap removers, etc., may be readily eliminatable, but may consume little energy and have only the consumed energy that is represented in the cost of the purchase. The second list, which includes the high-energy users at the top, will mean that if at the top of the list are significant fractions of total energy use in certain activities, then a 10 percent cut in that activity's energy use can make a significant contribution to the overall conservation effort. At the same time, a 100 percent reduction in an item at the bottom of the Ranking Energy Uses List that uses an insignificant fraction of the total energy will have no impact on a conservation program. Thus, it may not be cost effective at that point, because the cost of eliminating that activity may exceed the total energy consumed by that activity. This assumes one ignores the capital energy cost necessary to refine, manufacture, transport, and otherwise provide the materials and facilities, including appliances, etc., for that activity. This is very general. We will use some specific examples of these two lists to show what we mean. Let's take the Luxury List first. Figure 4.6 shows a generated luxury list that can be used for evaluation. Figure 4.7 shows a ranking list of energy users.

LIST OF LUXURIES

1. ELECTRIC CAN OPENER
2. BATTERY-POWERED CARVING KNIFE
3. ELECTRIC CREPES DISH
4. ORNAMENTAL LIGHTS, SUCH AS LAVA LAMPS
5. DECORATIVE GAS LIGHTS LEFT ON 24 HOURS A DAY
6. ORNAMENTAL EXTERNAL LIGHTS USED FOR DECORATIVE PURPOSES
7. EXTERNAL YARD LIGHTS
8. ELECTRIC COOKING, TOP COOKING APPLIANCES
9. MICROWAVE OVEN
10. ELECTRIC CLOTHES WASHER
11. ELECTRIC CLOTHES DRYER
12. ELECTRIC STOVE
13. REFRIGERATOR
14. LIGHTS AND LIGHTING SYSTEM
15. COOLING SYSTEM
16. HOT WATER SYSTEM

FIGURE 4.6

LIST OF RANKING ENERGY USES
AN EXAMPLE FROM HOUSTON, TEXAS

1. SPACE COOLING
2. SPACE HEATING
3. COOKING
4. HOT WATER
5. WASHING AND DRYING
6. LIGHTING
7. TELEVISION, RADIO, HOME ENTERTAINMENT
8. EXTERNAL YARD MAINTENANCE
9. MAINTENANCE AND IMPROVEMENT OF PROPERTY

FIGURE 4.7

included. One could or could not place transportation and automobile use in this list, depending upon whether energy conservation of that area is being considered at this time. In general, automobile use would be in the top third or top quarter of the energy-use categories in the demand listing. Where it would appear in the Luxury List depends on how necessary the car is, or seems to be. For breaking down automobile use for conservation purposes, one should separate required employment travel from travel that is used to maintain the residence (groceries, clothing, business, etc.), and these two travel categories should be separated from that for pure entertainment and personal discretionary travel for non-business or home maintenance use. The automobile has been left out of this example to simplify it because location of residence with respect to employment, shopping, etc., is an option that a person has only when moving, and this of course is highly constrained by the location of the job and the demography of the surrounding community. But anyone who is seriously interested in energy conservation over the long run should consider minimizing the miles and time spent in an automobile in getting to and from places of employment and shopping.

By this time, it should be obvious to all concerned that trade-offs from conservation methods are neither simple nor one-dimensional. The quality and quantity of the considered trade-off is of major importance in determining liability of consideration.

Assuming one has decided to conserve energy, and assuming one has decided what lifestyle and level is desired, then decisions can be made on prioritizing the energy conservation methods with respect to time and cost of improvements as compared to ultimate benefits and economic savings. It should be said in general that in a market of increasing energy costs, one does make an investment by reducing the energy demand of a particular facility or lifestyle. Increased energy costs mean that with time, the capital cost of making energy conservation modifications will increase, at least in proportion to the energy necessary to produce the materials used for the modifications. Prioritizing and indexing energy conservation options means that minimum money can be used to produce the maximum effect. This then frees the maximum amount of capital for use in the making of additional improvements in the near future. With time, the return on any investment of money and time in energy conservation will depend upon changes in the energy policy pricing structure.

The important point to be stressed in developing your own energy conservation priority system is that it should be designed to fit your own interests and lifestyle as much as possible. You have a certain amount of money which can be spent, within limits, to satisfy and maintain the desired lifestyle. Economics and political legislation will mandate a certain amount of energy conservation. The question will be whether your decisions are made in the areas of personal interest, when options are still there and the income flexibility is available; or whether these decisions must be made as a function of reduced energy or materials, increased costs, or shortages. In the latter case, one will get much less of a return for time and money spent on conservation options. Money spent on utility bills past the minimum levels required by a conservation philosophy within personal lifestyle limits is essentially discretionary money, and should be considered as such in all priority conservation analyses. One must, with respect to money, realize that you can either give it to the utilities by overspending for energy (which is the same thing as burning money), or save it and spend it on something else which is needed or desired. This means that gains can only be made by reducing energy demands and requirements, while at the same time saving money and possibly improving lifestyles. The important thing is to remember that energy conservation does not mean denial of personal preferences. This should be stressed very greatly in the presentation of energy conservation, on the setting of priorities, and the developing of a personal conservation plan. The students are referred to the previous ten modules for more specific details.

FIGURE 3

A SUMMARY OF ENERGY CONSERVATION METHODS FOR VARIOUS APPLICATIONS AND ACTIVITIES

After considering the conservation aspects of all the models and specifics of this module, one can summarize in numerical form what the better conservation activities and lifestyle approaches are that help reduce energy costs and utility bills. In general, a customer benefits from energy conservation because it:

1. Cuts down on utility and gasoline bills,
2. Helps fight pollution,
3. Saves natural gas, petroleum, and electricity now, so that such energy will be available longer.

Energy conservation methods are grouped under specific appliances and uses. The first list is for general residential and small commercial use, and the second list is for industrial and business use. However, many of the energy conservation practices for business and industry are directly applicable to the home, especially for those with electrical-electronic and audio-visual equipment.

I. GENERAL RESIDENTIAL AND SMALL COMMERCIAL CONSERVATION METHODS

A. Heating

1. In cooler months of the year, set the thermostat at 68° during the daytime, and several degrees lower at night (an extra blanket on your bed can make up the difference).
2. Set the thermostat at a comfortable temperature, then leave it alone...turning it up and down wastes energy.
3 Make sure the home has adequate insulation -- install storm windows and doors if not already in place. Three inches of insulation in attic can save as much as 25 percent on heating cost over no insulation.
4. Avoid frequent opening of outside doors. Use weatherstripping to seal air leaks around edges.
5. In winter, keep drapes open to let the sunlight in during the day; close them at night to stop cold drafts.
6. Keep the chimney damper closed when the fireplace is not in use.
7. Turn off heat vents and close off rooms that are not in use.
8. Keep filters clean...change them at least twice a year.
9. Consider a switch to solar heating in the future.
10. Remove furniture, rugs, etc., that block heating vents or radiators.
11. Place aluminum foil between radiator and exterior wall to reflect heat into the house.

B. Cooling

1. During hot months, set the temperature on "low" or keep the thermostat at 78° or more...this way less electricity will be used and occupants will feel less uncomfortable when you step outdoors.
2. In summer, close drapes to keep sunlight out to make it easier for the air conditioner to keep things cool.
3. Install a window air conditioner in the window with the most shade during the day.
4. Use heat-producing major appliances (dishwashers, dryers, ovens, etc.) during early morning or evening...not when the outside temperature is the highest.
5. Keep doors and windows closed when air conditioner is operating...and close off unused areas.
6. Keep filters clean.
7. Set the thermostat higher if the family is away most of the day and turn it off if you're going away for a weekend or longer.
8. Storm windows will help keep the cool air inside.
9. To ease the load on the air conditioning system, consider installing an attic fan to help blow out the trapped hot air.
10. Make sure sofas, bookcase, and other solid objects do not obstruct the air conditioning unit to help keep it operating efficiently.

C. Water Heating

1. Set the water heater thermostat at medium.
2. Take showers, which use less hot water than tub baths.
3. Fix leaky faucets (a drip a second wastes 700 gallons a year).
4. Don't wash dishes under running water...a dishwasher uses less hot water than hand washing.
5. Run washing machine, dryer, and dishwasher only with full loads. Wash clothes in cold water whenever possible.
6. When on vacation, set the water heater to the vacation setting. The pilot light will keep burning without using more energy to heat water. (Better still, turn the pilot light off.)
7. Don't waste hot water. For example, don't leave water running while washing hands or shaving--partially fill the basin first.

D. Lighting

1. Turn off lights when not needed.
2. Keep light bulbs and fixtures clean...brighter light may require fewer bulbs.
3. When possible, use fluorescent lamps. A 40-watt fluorescent lamp produces more light than a 100-watt incandescent bulb.
4. Install dimmer controls to save energy and add atmosphere where appropriate.
5. Use pastel walls and a light-colored interior decor, which usually requires fewer lamps.

E. Major Appliances--Kitchen Stove

1. Partially thaw frozen foods before cooking.
2. Put small pots on small burners, large ones on large burners.
3. Cover pots to avoid heat loss and reach cooking temperature quickly.
4. Use high setting on units to start, then reduce heat and food will continue to boil.
5. When cooking with water, use as little as possible so food will heat quickly.
6. When using the oven, preheat only 10 minutes...and don't peek. The oven uses less energy than the stove top because it is a confined space.
7. Avoid using aluminum foil on shelves directly under pans since it can reflect the heat away from them.
8. Cook by time and temperature. A meat thermometer can eliminate over-cooking. Precise timing eliminates heat wasted by peeking.
9. In summer, cook outdoors whenever possible to reduce heat build-up inside. Experiment with a solar cooker.
10. When using gas, regulate burners so flame tips just touch utensil bottoms.
11. A clean oven and broiler cooks more efficiently.
12. Ceramic, glass and stainless steel are best heat retainers (lower oven temperatures by 25°).

F. Major Appliances--Refrigerator/Freezer

1. Locate refrigerator out of sun and away from heat sources (stove, dishwasher, etc.)
2. Cool foods to room temperature before placing them in refrigerator.
3. Make sure gasket seals door well.
4. Defrost freezer when 1/4" of frost has built up.
5. Keep freezer full, but not overloaded: less energy is required to keep freezer cold when air can easily circulate around packages.
6. Chill food before placing it in freezer...and don't freeze too many things at once.
7. A chest freezer is more economical than an upright because when the door is opened the cold air settles on the bottom, rather than flowing onto the floor.
8. To avoid excess cold loss, open refrigerator or freezer only when necessary.
9. Check the temperature setting of your refrigerator and freezer against your appliance manual. If you store your food too cold, you will be wasting energy.
10. When preparing to go on vacation, set refrigerator at a warmer temperature and leave it fairly empty.

G. Major Appliances--Washer & Dryer

1. Keep the lint traps clean to assure top efficiency.
2. Use only when full and as cool a setting as possible (DO NOT OVERLOAD).
3. Use the water level control on your washer...small loads require less hot water.

4. Don't overdry clothes. Save ironing by hanging or folding clothes as soon as they are dry.
5. Your dryer should be located where it has easy access to clean dry air.
6. Use the free solar energy whenever possible.
7. Soak stubborn stains before washing.
8. Check type of soiling and fabric--when possible, wash clothes in cold water (except diapers).

H. Transportation

1. Reduce the amount of driving you must do...instead of five or six short trips make one well-planned and organized trip.
2. Use car pools to get to work, take kids to school, or even for shopping trips.
3. Use public transportation whenever possible.
4. Use a bicycle for short trips...uses less energy and keeps you in shape at the same time...Or walk.
5. Consider buying a smaller, more efficient car.

I. Automobile

1. Avoid jackrabbit starts and sudden stops.
2. Avoid weaving in and out of traffic; this wastes fuel and can cause needless accidents.
3. Save gasoline by turning off the car motor while waiting for someone.
4. Hold a constant driving speed when possible. Consider cruise control.
5. On hot summer days, park in the shade so the air conditioner doesn't have to work as hard. When possible, drive with the windows open.
6. Keep the car in top shape...have it tuned regularly.
7. Make sure tires are properly inflated to increase gas mileage and reduce wear.
8. If you are a two-car family, use the smaller one for running errands.
9. Change oil and oil filters every 3,000 to 6,000 miles (according to the owner's manual for particular model). A dirty engine wastes gas.
10. Improper wheel alignment cuts down on power, gas mileage, and tire mileage.

J. Appliances--General

1. Follow detergent directions carefully. Oversudsing in both dish and clothes washers uses extra energy because the equipment must work harder (try a low-suds product).
2. Use small appliances rather than large ones, when possible. For example, an electric fry pan uses less energy than an electric range burner in cooking a one-pot meal.
3. Iron all clothes at the same time to avoid reheating iron later in day or several times in one week.
4. Have gas appliances cleaned regularly so they will always operate at top efficiency.
5. Motor-driven appliances, like mixers, are particularly economical. Try hand mixing also.

K. Miscellaneous

1. Color television sets use more energy than black and white.
2. Always turn off a radio, TV, or record player when no one is watching or listening.
3. When possible, use major appliances during off-peak hours (before 8 a.m. and after 6 p.m.), when commercial and industrial use is less.
4. Keep a swimming pool in top operating condition so it doesn't waste energy.
5. Recycle aluminum, paper, and glass whenever possible.
6. Watch lawn watering...water is wasted when a lawn becomes saturated and the water starts running into the street.
7. Avoid using extension cords for major appliances and don't overload circuits. Overloading causes reduced energy efficiency.
8. Make the family aware of the energy problem and what they can do about it!

II. INDUSTRIAL AND BUSINESS

A. Heating

1. Install sufficient insulation.
2. Set the thermostat at 68° or slightly lower during the winter. (66-70° is recommended for factory areas, 72-74° for general office areas.) Avoid over-heating areas.
3. Cut heat leakage from building by using caulking and weather stripping around doors and windows.
4. Make sure heat is not left on too far into spring.
5. Reduce or turn off heat in unused areas (warehouses, docks, etc.).
6. Install automatic door closers on outside doors so they are not left open, thus heating the outdoors.
7. Reduce heating during those times when the space is unoccupied.
8. Check with equipment suppliers or qualified engineers to determine the extent to which heating, ventilating, and cooling equipment is suited for its job...is it the best?
9. Consider the practicality of infra-red heaters in high bay areas and warehouses. (It requires less fuel than other kinds of heating because it only heats solid objects in its path...not the air in between.)

B. Cooling

1. Keep the thermostat set at 72° or higher during the summer. Avoid overcooling.
2. Spray water on building roofs to reduce the effects of solar heat.
3. Close off unused areas.
4. Install automatic door closers on outside doors so they are not left open, thus cooling the outdoors.

C. Maintenance of Equipment

1. Emphasize boiler maintenance. Cleanliness improves its operation.
2. Check stack temperature to be sure of complete combustion.
3. Check the insulation on heat/cold pipes--machines will work extra hard because of leaks or a lack of proper insulation.
4. Inspect heat transfer surfaces regularly to make sure they are clean...insuring top efficiency.
5. Be on the alert for hot spots and deterioration in furnaces and pipe systems. (Air leaking into furnaces can cause large losses.)
6. Make sure furnace controls and burners are maintained for best efficiency.

D. Electricity

1. Turn off lights in empty rooms except where needed for safety and security (i.e., washroom lights).
2. Where possible, use fluorescent lighting rather than incandescent bulbs (for more lighting for less watts).
3. Turn off electrical equipment when not in actual use (e.g., typewriter while using the telephone).
4. Check and justify weekend electrical power usage.
5. Keep motor actuating controls in proper condition so that motors will not operate unnecessarily.
6. Install automatic controls for outdoor and indoor lighting so electricity is not wasted.
7. Convert to higher voltage electrical systems where practical.

E. Transportation

1. Reduce amount of driving...organize errands into one well-planned and organized trip rather than many short trips.
2. Encourage car pooling and the use of public transportation.
3. Whenever possible, ship freight by rail rather than by air... it requires less energy.
4. Keep company cars and trucks in top-shape...have them turned regularly.

F. Operation of Equipment

1. Avoid short runs on thermal process equipment when possible and shut down or idle equipment during production interruptions.
2. In many areas, energy waste is often the result of long-unquestioned plant practices that can be shown to have no effect on employee performance or product dependability... re-evaluate.
3. Schedule loads so equipment operates at top level of efficiency.

4. If possible, reschedule some electrical usage to off-peak periods when voltage remains high (before 8 a.m. or after 6 p.m.).

G. Miscellaneous

1. Recover waste heat from burner stacks and industrial processes use when possible.
2. Recycle waste materials (sawdust, oil, etc.) as supplemental fuels where possible.
3. Consider the use of heat pipes for transporting required heat or dissipating unwanted excess heat.
4. Check for accuracy of deliveries of oil, gases, etc.
5. Investigate "new" forms of energy.

These lists were developed using material from the Edmund Scientific Company Manual No. 9903

MODULE XI

ECONOMICS OF ENERGY CONSERVATION

POSTTEST

DIRECTIONS: Circle the word or words you believe to be the correct answer.

1. A car that is driven on the highway often will require a change of oil more often than one that is driven primarily in the city.

   a. true   b. false

2. Human comfort in any particular area is not a result of the loss of heat from the skin compared to the amount of heat internally generated by the body.

   a. true   b. false

3. Discretionary income in the family budget lies principally in food and energy.

   a. true   b. false

4. Usually it is possible for individuals to cut their energy use by a significant factor without lowering their standard of living.

   a. true   b. false

5. If plants grow high on your north wall, it is very likely that your heating costs will be increased.

   a. true   b. false

6. In using paper towels, one is not doing his/her best in conserving energy.

   a. true   b. false

7. The use of a microwave oven can reduce the amount of energy usually required to prepare meals.

   a. true   b. false

8. Air locks are of little benefit in controlling infiltration surges.

   a. true   b. false

9. Direct gain is an advantage in the winter.

   a. true   b. false

10. The maximum value of the instantaneous load is called the baseline load.

    a. true b. false

11. Actually, there are 4 major components in the time profile of the power demand.

    a. true b. false

12. The "baseline load" is the minimum constant demand on a utility generating facility.

    a. true b. false

13. If you are about to begin a program of energy conservation in your home, it is really of very little value to consider the kind of lifestyle you desire.

    a. true b. false

14. It is true that the energy contained in coal, oil, and natural gas came from the sun.

    a. true b. false

15. Not all power companies have the same load-following curve or load profile.

    a. true b. false

16. Power systems, such as hydroelectric generators, are capable of being ON and OFF with short duty times.

    a. true b. false

17. In some parts of the nation, there are different power rates for the summer and winter.

    a. true b. false

18. With rates rising, it is very unlikely that the conservation of electricity will reduce your bill.

    a. true b. false

19. The process of photosynthesis has an efficiency of about 1 percent.

    a. true b. false

20. When electricity is produced from fossil fuels, the maximum efficiency is about 1/3.

    a. true b. false

MODULE XI

ECONOMICS OF ENERGY CONSERVATION

ANSWERS TO POSTTEST

1. b. false
2. b. false
3. a. true
4. a. true
5. b. false
6. a. true
7. a. true
8. b. true
9. a. true
10. b. false
11. b. false
12. a. true
13. b. false
14. a. true
15. a. true
16. a. true
17. a. true
18. b. false
19. a. true
20. a. true

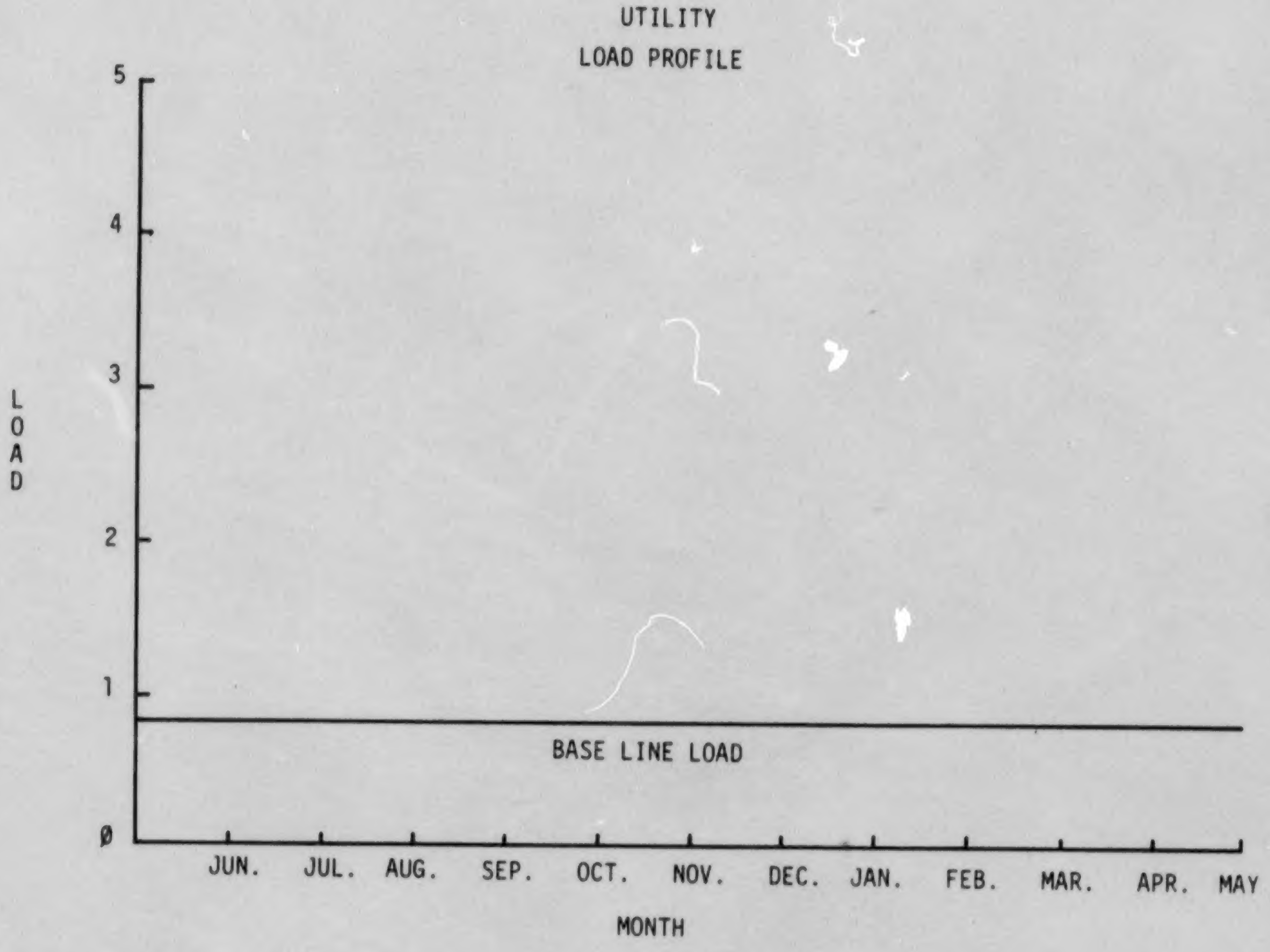

UTILITY
LOAD PROFILE
5
4
3
2
1
0
LOAD
BASE LINE LOAD
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
MONTH

FIGURE 1.1

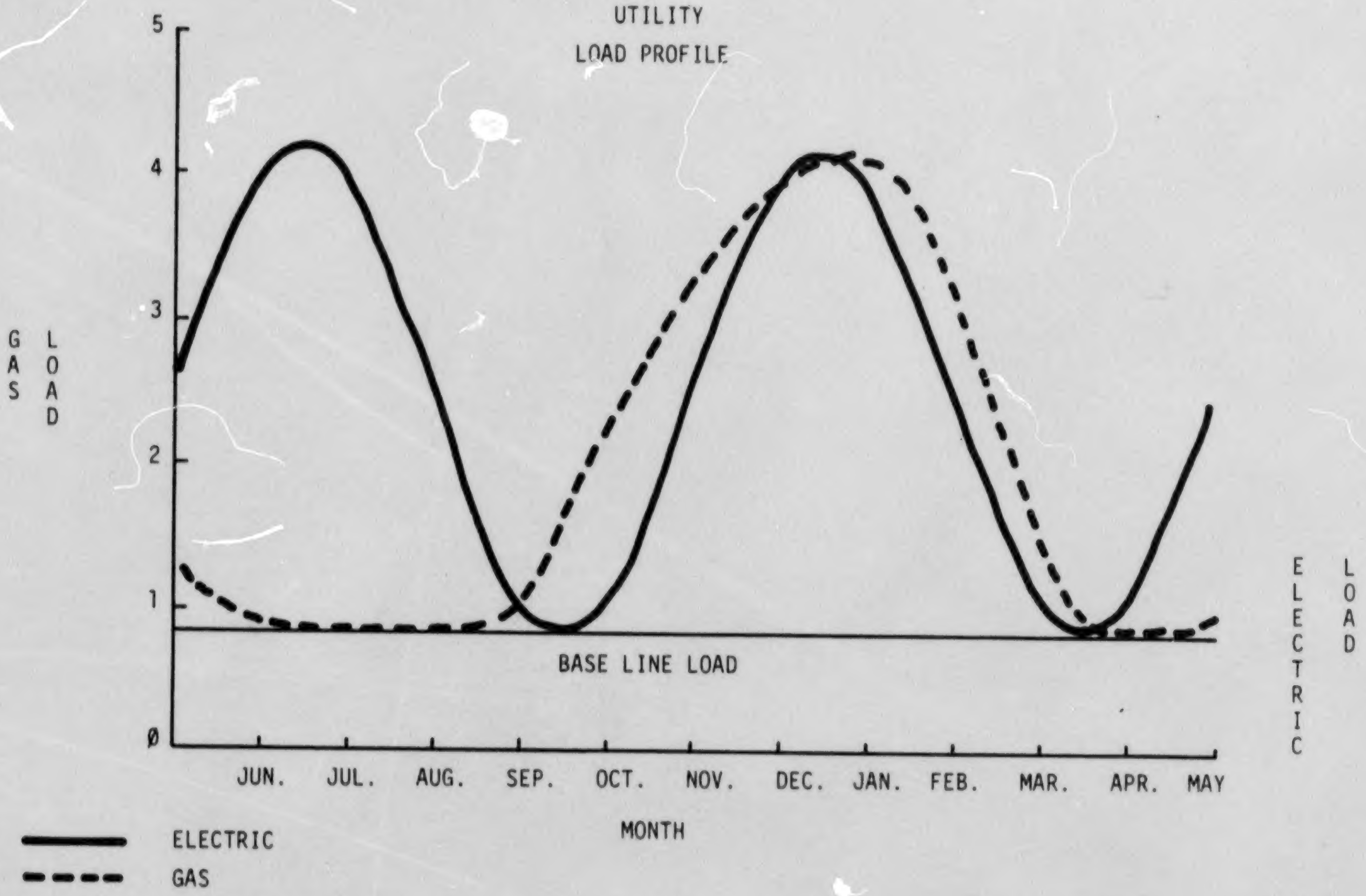
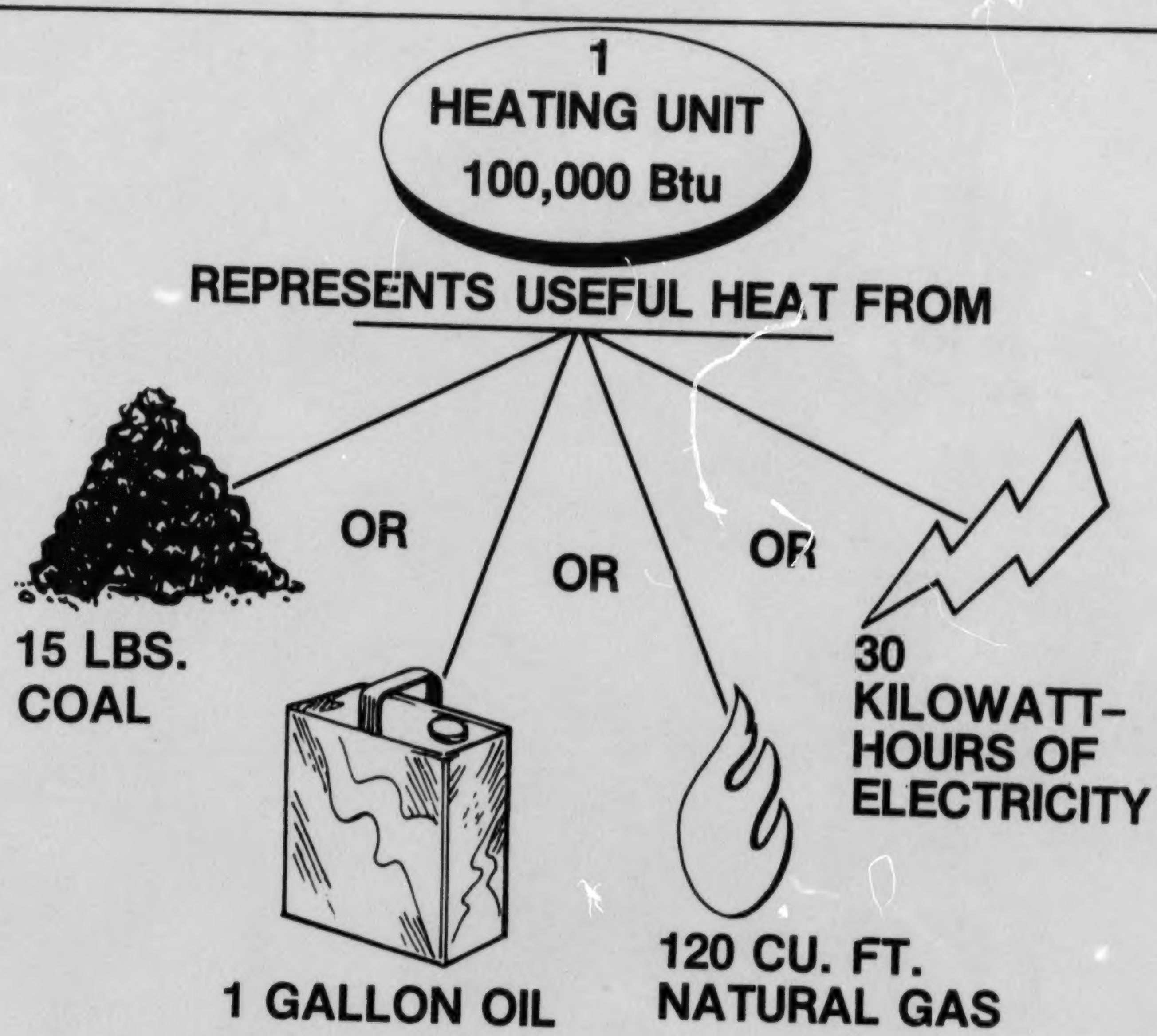

UTILITY
LOAD PROFILE
GAS LOAD
5
4
3
2
1
0
BASE LINE LOAD
ELECTRIC LOAD
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
MONTH
ELECTRIC
GAS

FIGURE 1.2



1
HEATING UNIT
100,000 Btu

REPRESENTS USEFUL HEAT FROM

15 LBS.
COAL

OR

1 GALLON OIL

OR

120 CU. FT.
NATURAL GAS

OR

30
KILOWATT-
HOURS OF
ELECTRICITY

FIGURE 1.3

LAMPS--EFFICIENCY

TYPE	LUMENS/WATT
Incandescent	8-22
Fluorescent	79
Mercury	30-65
Metal Halide	70-95
High-Pressure Sodium	110

FIGURE 2.3

ILLUMINATION

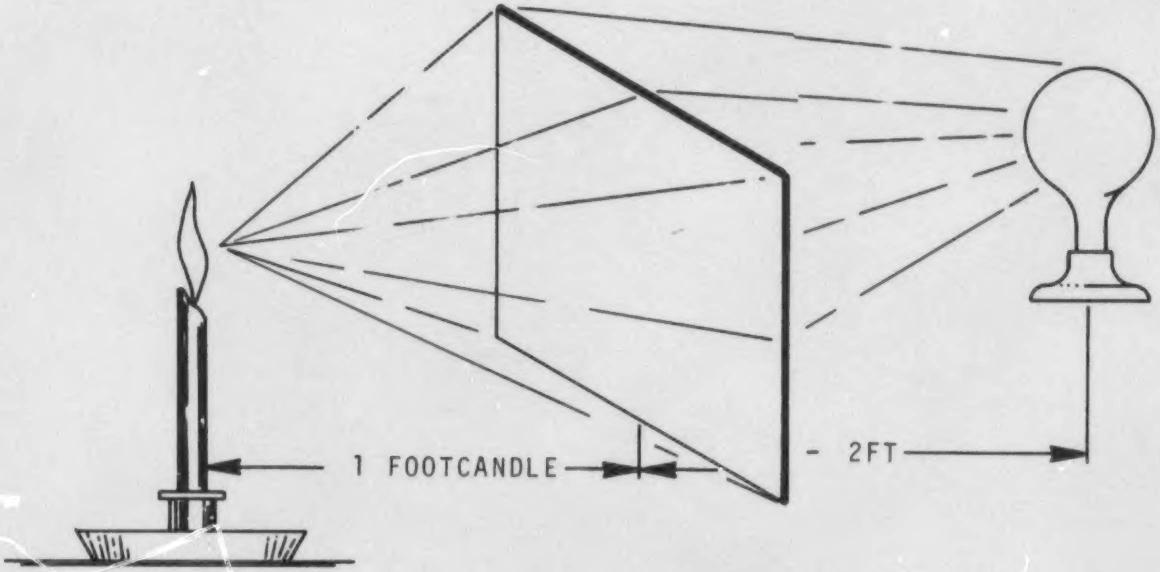

1 FOOTCANDLE
2FT

FIGURE 2.4

RETROFIT PACKAGE

TEXAS--EXCLUSIVE OF PANHANDLE

BASIC PACKAGE

INSTALL DAY/NIGHT CLOCK THERMOSTAT

ADD CEILING INSULATION TO ACHIEVE TOTAL OF APPROXIMATELY R-19

TUNE-UP FURNACE AND AIR CONDITIONING SYSTEM

WEATHERSTRIP EXTERIOR DOORS

SEAL ALL OPENINGS AND CRACKS IN EXTERIOR WALLS

CALIBRATE WATER HEATER TEMPERATURE

WEATHERSTRIP AND INSULATE ATTIC ACCESS DOOR

INSPECTION OF ENTIRE HOUSE FOR ADDITIONAL RECOMMENDATIONS

FIGURE 4.1

RETROFIT PACKAGE

TEXAS--EXCLUSIVE OF PANHANDLE

BETTER PACKAGE

ADD CEILING INSULATION TO ACHIEVE TOTAL OF APPROXIMATELY R-22

INSTALL R-11 FLOOR INSULATION ABOVE UNCONDITIONED SPACES

TAPE DUCT JOINTS AND INSULATE DUCTS IN UNCONDITIONED SPACES

INSTALL STORM WINDOWS IN ALL LIVING AREAS

BLOW INSULATION IN UNINSULATED EXTERIOR WALL CAVITIES

ADD OR INCREASE NATURAL ATTIC VENTILATION, IF NECESSARY

INSTALL CEILING FAN FOR SUMMER COOLING

FIGURE 4.2

PAYBACK PERIODS FOR RETROFIT
ENERGY CONSERVATION SYSTEMS
FOR DALLAS, TEXAS (1977)

TYPE OF WORK	TIME IN YEARS			
	HEAT PUMP	ELECTRIC RESISTANCE	GAS	OIL
ADD STORM SASH	12	7	16	6
ADD 6" INSULATION TO UNINSULATED ATTIC	3	2	3	2
INCREASE 3 1/2" INSULATION IN ATTIC TO 6"	7	5	8	5
BLOW 3 1/2" INTO SIDEWALLS	12	8	14	8

FIGURE 4.3

TYPICAL ANNUAL ENERGY USE PATTERNS
VARIOUS RESIDENTIAL CUSTOMERS

(ALL FIGURES IN KWH, EXCEPT FOR GAS APPLIANCES AS NOTED)

APPLIANCES NORMALLY IN USE	APARTMENT	SMALL HOME	AVERAGE HOME	LARGE HOME	ALL ELECTRIC HOME
COMFORT CONDITIONING INCLUDING:					
AIR CONDITIONER					
ROOM	650	1,389	2,100	--	--
CENTRAL	--	--	--	3,200	2,650
HEATING					
FURNACE - GAS (CCF)	(C.M.)[1]	(960)	(1,250)	(1,895)	--
FURNACE MOTOR	--	400	600	1,500	400[2]
ELECTRIC BASEBOARD	--	--	--	--	20,400
ELECTRIC AIR CLEANER	--	--	--	216	216
ATTIC FAN	--	--	--	291	--
WINDOW FAN	--	170	170	170	170
DEHUMIDIFIER	--	--	--	377	377
HUMIDIFIER	--	113	163	213	163
HEATING PAD	10	10	10	10	10
ELECTRIC BLANKET	--	147	147	147	147
TOTAL COMFORT CONDITIONING:	660	2,229	3,290	6,124	24,533
APPLIANCES:					
RANGE					
ELECTRIC	--	22[3]	900	900	300[4]
GAS (CCF)	(C.M.)[1]	(90)	--	--	--

902

FIGURE 4.4

903

APPLIANCES NORMALLY IN USE	APARTMENT	SMALL HOME	AVERAGE HOME	LARGE HOME	ALL ELECTRIC HOME
LAUNDRY:					
WRINGER WASHER	--	76	--	--	--
AUTOMATIC WASHER	--	--	103	103	103
DRYER					
ELECTRIC	--	100[3]	100[3]	993	993
GAS - WITH PILOT (CCF)	--	(65)	--	--	--
GAS - ELECTRIC IGNITION (CCF)	--	--	(45)	--	--
IRON	144	144	144	144	144
WATER HEATER					
ELECTRIC	--	--	--	--	4,800
GAS (CCF)	(C.M.)	(325)	(325)	(325)	--
TOTAL LAUNDRY	144	320	347	1,240	6,040
ENTERTAINMENT:					
RADIO(S)	86	86	172	172	172
STEREO	--	109	109	109	109
T.V. (B&W)	--	--	362	362	362
T.V. (COLOR)	502	502	502	502	502
TOTAL ENTERTAINMENT	588	697	1,145	1,145	1,145

FIGURE 4.4 (cont)

APPLIANCES NORMALLY IN USE	APARTMENT	SMALL HOME	AVERAGE HOME	LARGE HOME	ALL ELECTRIC HOME
MICROWAVE OVEN	--	--	--	--	300
DISHWASHER	363	--	363	363	363
TOASTER	39	39	39	39	39
MIXER	13	13	13	13	13
COFFEE MAKER	106	106	106	106	106
BLENDER	--	--	15	15	15
DISPOSAL	--	--	30	30	30
HOTPLATE	90	90	--	--	--
FRYING PAN	--	186	186	186	186
BROILER	--	--	--	100	100
DEEP FRYER	--	83	83	83	83
WAFFLE IRON	--	22	22	22	22
TRASH COMPACTOR	--	--	--	50	50
SANDWICH GRILL	--	--	--	33	33
ROASTER	--	--	250	205	205
CARVING KNIFE	--	--	3	3	3
TOTAL APPLIANCES:	611	539	1,965	2,148	1,848
FOOD PRESERVATION:					
REFRIGERATOR					
12 CU. FT.	728	--	--	--	--
14 CU. FT. - FROSTLESS	--	1,829	1,829	1,829	1,829
FREEZER					
15 CU. FT. - FROSTLESS	--	--	--	1,761	1,761
TOTAL FOOD PRESERVATION	728	1,829	1,829	3,590	3,590

FIGURE 4.4 (cont)

ENERGY COSTS AND EFFICIENCY OF CONVERSATION

(1) HEAT CONTENT OF FUELS

ELECTRICITY	3412 BTU/KWHR
NATURAL GAS	1050 BTU/Ft3
COAL	1310 BTU/GAL
OIL	141,000 BTU/GAL

(II) EQUIPMENT EFFICIENCIES

	RECOMMENDED NEW	USUAL & AVERAGE	IF KNOWN
(A) COOLING			
(1) ELECTRIC	2.05	1.47	EER/3.412
(2) GAS ABSORPTION	.48	.27	COP
(B) HEATING			
(1) ELECTRIC RESISTANCE	1	1	1
(2) ELECTRIC HEAT PUMP	2.25	2.25	SEASONAL PERFORMANCE
(3) FURNACE (GAS)	.75	.55	EFFICIENCY

FIGURE 4.5

LIST OF LUXURIES

1. ELECTRIC CAN OPENER
2. BATTERY-POWERED CARVING KNIFE
3. ELECTRIC CREPES DISH
4. ORNAMENTAL LIGHTS, SUCH AS LAVA LAMPS
5. DECORATIVE GAS LIGHTS LEFT ON 24 HOURS A DAY
6. ORNAMENTAL EXTERNAL LIGHTS USED FOR DECORATIVE PURPOSES
7. EXTERNAL YARD LIGHT
8. ELECTRIC COOKING, TOP COOKING APPLIANCES
9. MICROWAVE OVEN
10. ELECTRIC CLOTHES WASHER
11. ELECTRIC CLOTHES DRYER
12. ELECTRIC STOVE
13. REFRIGERATOR
14. LIGHTS AND LIGHTING SYSTEM
15. COOLING SYSTEM
16. HEATING SYSTEM
17. HOT WATER SYSTEM

FIGURE 4.6

LIST OF RANKING ENERGY USES
AN EXAMPLE FROM HOUSTON, TEXAS

1. SPACE COOLING
2. SPACE HEATING
3. COOKING
4. HOT WATER
5. WASHING AND DRYING
6. LIGHTING
7. TELEVISION, RADIO, HOME ENERTAINMENT
8. EXTERNAL YARD MAINTENANCE
9. MAINTENANCE AND IMPROVEMENT OF PROPERTY

FIGURE 4.7

MODULE XII

BIBLIOGRAPHY

This module is to support a group of 11 modules in an energy conservation curriculum for secondary and postsecondary vocational students. It is intended as a comprehensive bibliography of audiovisuals, books, games, government documents, journals and periodicals, and reports to supplement the educational material contained in the modules of the curriculum. Limited bibliographies are included with each module.

MODULE XII

BIBLIOGRAPHY

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MODULE XII

BIBLIOGRAPHY

AUDIOVISUALS

Filmstrips

Concepts in Science Sound Filmstrips, Green--A Series. Guidance Assoc., Division of Harcourt, Brace, Jovanovich, Inc., 757 Third Ave., New York, NY 10017. 1973.

Cube and Clip--A Probe into Changes in Matter
Moon Shapes--A Probe into the Phases of the--
Moving Water--A Probe into the Water Cycle--
Records From the Past--A Probe into Fossil--
Uses of Dirt--A Probe into Conservation--
Where Does It Fit--A Probe into Common--

Conservation of Matter and Energy (from The Concepts in Science, Set 8 Series). Eye Gate House, Inc., 146-01 Archer Ave., Jamaica, NY 11435. 1974. Filmstrip with cassette/script: 47 frames.

Conservation and Natural Resources

Energy--Today and Tomorrow (from The Concepts in Science, Set 8 Series). Eye Gate House, Inc., 146-01 Archer Ave., Jamaica, NY 11435. 1974. Filmstrip with cassette/script: 56 frames.

Conservation and Natural Resources

Energy and You--Conserving Energy. Visual Education Consultants, Box 52, 2066 Helena St., Madison, WI 53701. Filmstrip with script: 42 frames.

Presents hints on ways to conserve energy in everyday living.

Energy Ant Filmstrip Set, The, Part 1--What Is Energy. U. S. National Audiovisual Center, General Services Administration, Washington, DC 20409. 1977. Filmstrip with cassette: 48 frames.

Presents Energy Ant, who describes the various aspects of energy, including what it is, where it comes from, and how it can be saved.

Energy Ant Filmstrip Set, The, Part 2--What Is Energy Conservation. U. S. National Audiovisual Center, General Services Administration, Washington, DC 20409. 1977. Filmstrip with cassette: 49 frames.

Presents Energy Ant, who describes the various aspects of energy, including what it is, where it comes from, and how it can be saved.

Energy Conversion and Conservation (from The Science Enrichment Sound Filmstrip, Level 1 Series). Producer: Ed Media Tec, P. O. Box 230, Wilkes-Barre, PA 18703. Distributor: Silver-Burdett Co., 250 James St., Morristown, NJ 07960. 1975. Filmstrip with cassette/script: 53 frames.

Illustrates several examples of energy conversion, emphasizing that the total amount of energy within a system and within the entire universe remains constant.

Energy Crisis, The--An Historical Review (from The School Times Kit--April Series). Teaching Resources Films, Now Educational Enrichment. 1972. Filmstrip with record/script: 45 frames.

Presents a picture of the forces with which people need to work and what forms of energy lie ahead.

Finding Out--A Probe Into Push and Pull (from The Concepts in Science Sound Filmstrips, Blue Series). Guidance Assoc., Division of Harcourt, Brace, Jovanovich, 757 Third Ave., New York, NY 10017. 1972. Filmstrip with record/cassette/script: 31 frames.

Investigates the concept of energy conservation in physics.

Harnessing the Sun. National Geographic Society, Special Publication and Educational Filmstrip Division, 17th and M St., NW, Washington, DC 20047. Filmstrip with cassette: 44 frames.

Introduces the concept of solar energy and examines methods and devices developed to capture it.

Man's Use and Control (from The Advanced Elementary Science Series). Colonial Films, 4315 NE Expressway, Atlanta, GA 30341. 1961. Filmstrip with captions: 46 frames.

Describes how people use natural resources and energy and the machines to do their work. Shows how they have improved their environment; and emphasizes the importance of conservation.

Search for Power and Energy, The (from The Industry and Technology Series). Walt Disney Productions, Educational Film Division, 500 S. Buena Vista St., Burbank, CA 91521. 1973. Filmstrip with record/cassette/script: 73 frames.

Uses cartoons to trace the continuing search for sources of inexpensive, abundant, and efficient energy. Concludes with the present dilemma to protect the environment while developing alternate power potentials.

School Times Kit--April--A Series. Teaching Resources Films, Now Educational Enrichment. 1972.

Energy Crisis, The--An Historical Review
Energy Crisis, The--Report from Planet 32

Wide World of Energy, The. Walt Disney Educational Media Co., 500 S. Buena Vista St., Burbank, CA 91521. 1976. Filmstrip with cassette: 73 frames.

Introduces the issue of energy conservation, focusing on use of reasoning power in dealing with the demand for energy. Stresses the importance of assuming personal responsibility for conservation.

Motion Cartridges

Basic Ideas in Physical Science, Set 5--Energy Conservation and Change--A Series. Doubleday Multimedia. 1975.

Deals with energy conservation, conversion and change.

Conservation of Energy (from The Mechanics on an Air Track Series). Ealing Corp., 2225 Massachusetts Ave., Cambridge, MA 02140. 1966. 8mm Cartridge Silent: 3 minutes.

Presents the three examples of transformation of work into kinetic energy with sufficient data to permit calculation of the kinetic energy.

Conservation of Energy--Potential to Kinetic. Holt, Rinehart and Winston, 383 Madison Ave., New York, NY 10017. S8mm Cartridge Silent: 3 minutes.

Demonstrates three examples of the principle of conservation of energy. Illustrates kinetic energy, gravitation potential energy, and elastic potential energy.

Conservation of Energy--The Pendulum and the Piledriver. Ealing Corp., 2225 Massachusetts Ave., Cambridge, MA 02140. 1968. S8mm Cartridge Silent: 4 minutes.

Analyzes a simple pendulum and observes how well the mechanical energy is conserved. Uses a homemade piledriver to illustrate the loss of mechanical energy.

Conservation of Mechanical Energy--A Series. BFA Educational Media, 2211 Michigan Ave., P. O. Box 1795, Santa Monica, CA 90406. 1973.

Makes graphic analyses of the motions of rolling spheres, projectiles, and pendula. Shows that a moving body has both kinetic and potential energy.

Elastic and Inelastic Collisions (from The Experiments in Physics--Mechanics Series). Walter De Gruyter, Inc., 162 Fifth Ave., New York, NY 10010. 1973. S8mm Cartridge Silent: 4 minutes.

Demonstrates the equations for conservation of energy and momentum. Shows elastic and inelastic collisions between pairs of moving bodies with equal or unequal masses, with the motion of the bodies on the air track being almost frictionless.

Energy Conservation (from The Basic Ideas in Physical Science, Set 5--Energy Conservation and Change Series, Module B). Doubleday Media. 1975. S8mm Cartridge Silent: 4 minutes.

Basic Physical Science--Energy and Matter

Energy Conservation in a Simple Pendulum (from The Conservation of Mechanical Energy Series). BFA Educational Media, 2211 Michigan Ave., P. O. Box 1795, Santa Monica, CA 90406. 1973. S8mm Cartridge Silent: 4 minutes.

Physics--Energy and Matter; Physics--Force and Motion

Motion Pictures

Conservation of Energy (from The Introductory Physics-Mechanics Series). Producer: Encyclopedia Britannica Films. Distributor: Encyclopedia Britannica Educational Corporation, 425 N. Michigan Ave., Chicago, IL 60611. 1957. 16mm Film Optical Sound: 30 minutes.

Explains and demonstrates energy conservation as applied to kinetic and potential energy.

Conservation of Energy (from The PSSC Physics Film Series). Producer: Physical Science Study Committee. Distributor: Modern Learning Aids Division of Ward's Natural Science, P. O. Box 1712, Rochester, NY 14603. 1960. 16mm Film Optical Sound: 27 minutes.

Traces energy from coal to electrical output in a large power plant. Demonstrates the conservation law for random and orderly motion.

Easy Energy. American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209. 1975. 16mm Film Optical Sound: 6 minutes.

Considers whether today's easily available energy sources are being wisely used and what can be done to conserve energy.

Energy (from The Economics for Elementary Series). Oxford Films, Inc., 5451 Marathon St., Hollywood, CA, Paramount-Oxford Films (Now Paramount Communications). 1974. 16mm Film Optical Sound: 10 minutes.

Explores the subject of energy in human beings, animals, the elements, and the earth. Shows how these different kinds of energy are harnessed and the ways in which they are used daily in home and industry. Points out that pollution is a result of excess use and barren devastation, a result of a lack of thoughtful conservation.

Energy--Choices, Options, Decisions (from The Screen News Digest Series, Vol. 17, Issue 4). Hearst Metrotone News, 235 East 45th Street, New York, NY 10017. 1974. 16mm Film Optical Sound: 14 minutes.

Examines the search for new means of meeting America's continuing energy challenges. Explores energy sources and conservation, research, and development that will serve the public good and promote the national interest.

Energy Challenge, The (from The Screen News Digest Series, Vol. 16, Issue 1). Hearst Metrotone News, 235 East 45th St., New York, NY 10017. 1973. 16mm Film Optical Sound: 26 minutes.

Discusses the causes and effects of the energy shortage, problems and opportunities, and various plans and proposals.

Energy Crisis Series--Future Fuels. Producer: National Broadcasting Co., Educational Enterprises, 30 Rockefeller Plaza, New York, NY 10020. Distributor: Films, Inc., 1144 Wilmette, Wilmette, IL 60091. 16mm Film Optical Sound: 17 minutes.

Contrasts the need for new available energy sources with the fact that nobody seems to be looking very hard.

Energy Sources of the Future. McGraw-Hill Films, 1221 Avenue of the Americas, New York, NY 10020. 1974. 16mm Film Optical Sound: 15 minutes.

Examines the state of energy resources in the world today. Shows how new sources of energy, such as nuclear fission and fusion, solar heat, and wind energy, are being investigated as possible replacements for dwindling resources of fossil fuels.

Energy Vs. Ecology--The Great Debate. Producer: Allis Chalmers Manufacturing Co. Tractor Group. Distributor: Modern Talking Picture Service, 2323 New Hyde Road, New Hyde Park, NY 11040. 1973. 16mm Film Optical Sound: 28 minutes.

Describes the role that coal plays in meeting the ever-increasing demands for electrical energy in the United States.

Environment, The (from The Energy Crisis Series). Producer: National Broadcasting Co. Educational Enterprises, 30 Rockefeller Plaza, New York, NY 10020. Distributor: Films, Inc., 1144 Wilmette, Wilmette, IL 60091. 16mm Film Optical Sound: 11 minutes.

Presents a report of the Alaskan pipelines and explains that when the biggest oil field on the continent was discovered at Prudhoe Bay, Alaska, oil companies wanted to build a pipeline down to the lower 48 states. Describes the viewpoint of the environmentalists who said it would ruin the Alaskan habitat and kill many of the animals.

Fusion--The Electric and Infinite Future (from The Towards the Year 2000 Series). Document Associates, Inc., 211 East 43rd St., New York, NY 10017. 16mm Film Optical Sound.

Discusses fusion as the replacement for fission as a source of energy. Features Dr. Harold Furth, a physicist in the Princeton plasma physics lab, who explains the problems faced by scientists in developing this technique before time and the fuels run out. Presents Ralph E. Lapp, nuclear physicist and author of Nuclear Power and the Environment, who points out that the cost of fusion reactors is so astronomical that only the wealthy can afford them.

Geothermal--Nature's Boiler. 1977. 16mm Film Optical Sound: 7 minutes.

Explains how natural heat energy stored in and under the earth's crust can be made into a visible energy source.

Molecules in Motion (from The Laws of Disorder--An Introduction to Chemical Change and Thermodynamics Series). Producer: British Broadcasting Co-TV, 630 Fifth Ave., New York, NY 10020. Distributor: Peter M. Robeck and Co., Inc., Distributed by Time-Life Films, Inc., 20 Biekman Place, New York, NY 10022. 1969. 16mm Film Optical Sound: 30 minutes.

Presents Professor George Porter, Nobel Prize winner, who lectures on the first law of thermodynamics, the law of conservation of energy. Explains that heat is another word for the random kinetic energy of molecules, and is one form of energy which may be converted into other forms.

Moving With the Center of Mass (from The PSSC Physics Film Series). Producer: Physical Science Study Committee. Distributor: Modern Learning Aids Division of Ward's Natural Science, P. O. Box 1712, Rochester, NY 14603. 1966. 16mm Film Optical Sound: 26 minutes.

Demonstrates the conservation of energy and momentum of several magnetic dry ice pack interactions. Discusses and illustrates the partition of energy into two parts--one associated with the motion of the center of mass and the other associated with the motion of the parts with respect to the center of the mass.

Positron-Electron Annihilation (from The Physics Film Series). Producer: Educational Development Center Exploring Childhood Program. Distributor: Universal Education and Visual Arts, 100 Universal City Plaza, Universal City, CA 91608. 1967. 16mm Film Optical Sound: 28 minutes.

Demonstrates the annihilation of positron-electron pairs. Emphasizes the conservation of energy and the transformation of matter into radiation.

Saving Energy At Home. Ramsgate Films, 704 Santa Monica Blvd., Santa Monica, CA 90401. 1975. 16mm Film Optical Sound: 13 minutes.

Identifies the major sources of energy waste in the home and offers tips on how to cut down on home energy consumption.

Solar Energy and You. Producer: Fine Arts Communicators. Distributor: Consumers Power Co., 212 W. Michigan Ave., Jackson, MI 49201. 1977. 16mm Film Optical Sound: 19 minutes.

Reviews the field of solar energy. Shows efforts at utilizing solar power and projected application for the future.

Talk Was of Energy, The. Producer: American Petroleum Institute, 2101 L. Street NW, Washington, DC 20037. Distributor: Modern Talking Picture Service, 2323 New Hyde Road, New Hyde Park, NY 11040. 1971. 16mm Film Optical Sound: 29 minutes.

Demonstrates the need to acquire energy from natural sources but at the same time preserve the environment.

To Bottle the Sun. Producer: National Science Foundation, 1800 G St., NW, Washington, DC 20550. Distributor: Doubleday Multimedia. 1973. 16mm Film Optical Sound: 5 minutes.

Explores the possibility of fusion power reactors as an alternative way of satisfying future expanding energy needs with coal, gas and oil in limited supply.

Waste Heat Management--Energy Utilization for Profit (from The Industrial Energy Conservation Series). 1976. 16mm Film Optical Sound: 26 minutes.

Shows how waste heat from various industrial processes can be captured and reused to help cut industrial fuel bills and thereby increase profits, while at the same time helping to conserve the nation's energy supply. Includes several waste heat recovery systems and techniques. Discusses how waste heat management programs have permitted industry spokespersons to maintdin productivity with less fuel.

Which Energy (from The Science of Energy Series). Stuart Finley, Inc., 3428 Mansfield Road, Falls Church, VA 22401. 1976. 16mm Film Optical Sound: 23 minutes.

Compares different energy sources by visiting field installations and research laboratories. Considers fossil fuels, nuclear fusion, fission, the breeder reactor, solar energy, wind, and conservation concepts.

Record

Energy and Motion Songs (from The Ballads for the Age of Science Series). Motivation Records, Stanley Bowmar Co., 4 Broadway, Valhalla, NY 10595. 33 1/3 RPM. 12-inch record: 2 sides.

Presents Tom Glazer and Dottie Evans singing about different kinds of energy, including chemical, mechanical, heat and atomic. Deals with the conservation of energy, molecular motion, and jet engines.

Transparency

Conservation of Energy--Matter (from The Energy Series). AEVAC, Inc., 1500 Park Ave., South Plainfield, NJ 07080. 8 x 10 Prepared Transparency.

Basic Physical Science--Energy and Matter; Physics--Energy and Matter

Video Tapes

Bottom of the Oil Barrel, The. Producer: British Broadcasting Co-TV, 630 Fifth Ave., New York, NY 10020. Distributor: Time-Life Films, Inc., 43 W. 16th St., New York, NY 10011. 1974. 3/4 inch video cassette: 34 minutes.

Examines the current energy crisis. Discusses how petroleum deposits are rapidly being depleted, and considers alternative sources of energy. Points out how the present domination of oil reserves by Middle Eastern powers could have adverse effects on the rest of the world.

Process and Proof--A Series. Producer: Metropolitan Cleveland Educational Television Corp. Distributor: Great Plains Instructional TV Library, University of Nebraska, P. O. Box 80669, Lincoln, NE 68501.

Studies the solution of scientific problems through legitimate investigative processes, and the proofs which lead to and culminate in those solutions. (Broadcast quality)

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Conservation I
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Conservation III
Conservation IV
Conservation V
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Food Web, The
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Luminescence and Incandescence
Nature of Light, The
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The object of the game is to advance through a 48-month period on the board, paying energy and utility bills as they occur, and purchasing energy conservation options best suited for particular energy systems. The winner is the person who best manages the $10,000 given each player at the beginning of the game.

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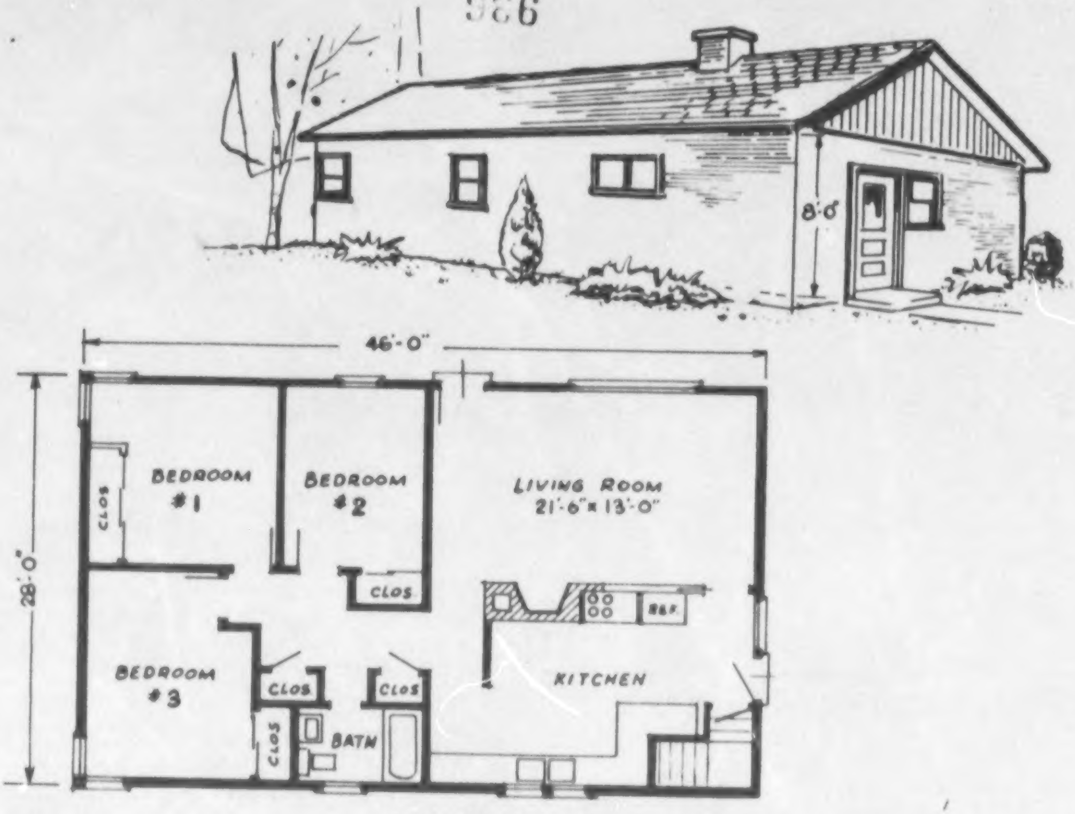

FIGURE 2.5

The Quick, Easy Calculations

WALLS Take the walls first. Walk around the house measuring its perimeter. In this example, it is 46 ft. *plus* 28 ft. *plus* 46 ft. *plus* 28 ft. or a total of 148 ft., which is entered on the form. Now, measure the ceiling height (8 ft). Multiplying these two figures (148 x 8) gives a total wall area of 1184 sq. ft.

Using the -10° column in the multiplier table, a figure of "11" is shown for insulated walls. Multiplying these figures (1184 x 11) gives a wall heat loss of 13,024 BTUs.

GLASS Count the number of windows (10) and multiply by "15." This gives a figure of 150 sq. ft. for windows. Similarly, count the number of doors (2) and multiply by "20" for a square foot figure of 40. Adding windows (150) and doors (40) gives a total glass area of 190. The multiplier for windows and doors without storm sash at -10° is "60". Multiplying these figures (190 x 130) gives the BTU heat loss of 24,700.

CEILING Ceiling area is the length of the house times its width (46 x 28) for a total of 1288 sq. ft. The multiplier for an insulated ceiling at -10° is "8." The heat loss of the ceiling then is (1288 x 8) or 10,304 BTUs.

FLOOR As the house has a full basement in which the furnace will be, the multiplier is "O". Therefore, the area of the floor need not be considered (since O x anything is still "O") . . . and the heat loss through the floor is nothing ("O").

TOTAL HEAT LOSS This is just the sum of the individual heat losses (13,024 plus 24,700 plus 10,304 plus 0) which is a total of 48,028 BTUs. This indicates the total amount of heat (in BTUs) that will be needed in the house. To obtain this amount of heat requires a furnace with an output rating (at the registers) of 48,028 BTUs, or more.

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HEATING ESTIMATE WORK SHEET

X-133

TYPE OF HOUSE __________ STORY

- ● ATTIC INSULATION ☐ YES ☐ NO
- ● WALL INSULATION ☐ YES ☐ NO
- ● STORM SASH ☐ YES ☐ NO

DESIGN TEMPERATURE
OUTSIDE __________ °F
INSIDE __________ °F
DIFFERENCE __________ °F

TYPE OF EXPOSURE		GROSS AREA IN SQUARE FEET	×	MULTIPLIER	=	HEAT LOSS IN BTU'S
EXPOSED WALLS		PERIMETER × CEILING HT = SQ. FT. 148 × 8 = 1184	×		=	
GLASS	NO. OF WINDOWS	10 × 15 = 150				
	NO. OF DOORS	2 × 20 = 40				
	TOTAL GLASS	190	×	130	=	24,700
COLD CEILING		LENGTH × WIDTH = SQ. FT. 46 × 28 = 1288	×	8	=	10,304
COLD FLOOR			×	0	=	0

TOTAL HEAT LOSS IN BTU'S NEEDED AT REGISTER OR RADIATOR ➧ 48,028

MULTIPLIERS

TYPE OF CONSTRUCTION		MULTIPLIERS FOR 70° AT OUTSIDE DESIGN TEMPERATURE						
		−30	−20	−10	0	+10	+20	+30
WALLS	FRAME OR BRICK VENEER STANDARD WALL NO INSULATION	26	24	21	18	15	13	10
	WITH 2" OR MORE INSULATION	13	12	11	9	8	6	5
WINDOWS DOORS	PLAIN SINGLE GLASS	170	150	130	120	105	85	65
	WITH STORM SASH	80	70	60	55	50	40	30
CEILINGS	ATTIC ABOVE—NO INSULATION	32	29	25	22	19	15	12
	ATTIC ABOVE—3½" INSULATION	10	9	8	7	6	5	4
FLOORS	OVER BASEMENT (with furnace)	0	0	0	0	0	0	0
	OVER ENCLOSED CRAWL SPACE—4" INSULATION	5	5	4	4	3	3	2
	OVER ENCLOSED CRAWL SPACE—NO INSULATION	14	13	11	10	9	7	6
	OVER UNENCLOSED CRAWL SPACE	28	25	22	20	17	14	12
	ON A 4" CONCRETE SLAB	10	9	8	7	6	5	4

HOW TO USE WORK SHEET

There is only one "cold" ceiling — the one immediately below the attic. "Cold" floors are over an open area, on a concrete slab, or over an unexcavated area. Measure the length and width of these surfaces. When you have the measurements and other information filled in, figure the areas by multiplying the length times the width, as indicated on the work sheet.

Total area of exposed walls is the house perimeter (distance in feet around the outside) times ceiling height. For houses with more than one story, total the ceiling heights of all levels except basement, before multiplying by perimeter.

Multiply each of these areas by its indicated construction factor called a "multiplier" . . . to be found in the "MULTIPLIERS" Table on the work sheet. The answers will be in BTUs and will show the heat loss. Equipment is rated in BTUs, so if the total heat loss of the house is known, it is easy to pick a furnace or boiler of the proper size from the *Wards* Catalog.

DETERMINING THE HEAT LOSS FOR A SAMPLE HOUSE

The Type of House

In estimating the heat loss of a sample house *(page 17)*, information and calculations are entered on the Work Sheet as shown above. Here is where they come from . . .

This is a single story house with a full basement. Both the walls and the attic have insulation, but the doors and windows are not protected by storm sash. The design temperature is −10°.

FIGURE 2.4

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